Pleistocene Stratigraphy of Illinois

H. B. Willman and John C. Frye

ILLINOIS STATE GEOLOGICAL SURVEY BULLETIN 94
Urbana, Illinois 61801 1970

Printed by Authority of State of Illinois, Ch. 127, IRS, Par. 58.25

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Topographic mapping in cooperation with the United States Geological Survey.

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Manuscript submitted for printing July 14, 1970

PLEISTOCENE STRATIGRAPHY OF ILLINOIS

H. B. Willman and John C. Frye

ABSTRACT

The near-surface rocks of Illinois, the Glacial or Pleistocene deposits, are intimately involved in man's activities and have been studied scientifically for more than 100 years. The systematic classification of these rocks that is presented here is designed to meet the needs of applied science as well as the requirements for basic stratigraphic research.

In keeping with the concept of multiple classification in stratigraphy developed during the past two decades, four classification schemes—rock-stratigraphic, soil-stratigraphic, morphostratigraphic, and time-stratigraphic—are presented for the Pleistocene of Illinois. Each is based on its own set of characteristics and is designed to serve special needs. In each, units are named and described for use in Illinois. Also discussed are the geologic setting of the surficial deposits and the general principles of classification.

Included with the report are tabulated data on mineral composition and grain size, radiocarbon dates, details of stratigraphic successions, and a glossary of formerly used terms. Maps and diagrams show the relations of the various units and their geographic distribution in Illinois.

INTRODUCTION

The activities of man are in one way or another concerned with nearly all of the surface area of Illinois, and nearly all of the deposits underlying that surface are a product of geologic events during Pleistocene time. These are the deposits on and in which highways and cities are built, the agricultural soils have developed, and most of our waste materials are sequestered. These deposits have a major influence on drainage and recharge to our ground-water reservoirs, and from them we produce needed supplies of sand and gravel, ground water, fill earth, clays for brick manufac-

ture, and other products. This report provides a state-wide scheme for the classification and nomenclature of these near-surface deposits.

Since the latter part of the last century, a great amount of research has been devoted to the Pleistocene of Illinois, and much of the data presented in this report has been drawn from the results of other workers, whose reports are listed in the accompanying bibliography. The prime contribution here is the formulation of a systematic classification under which individual units can be readily identified, mapped, described, and correlated throughout the state. Like all classification systems, the one presented here should be considered as dynamic rather than static and is intended to be modified and expanded as the need develops.

In glacial Pleistocene geology, Illinois occupies a unique position in North America. It is the region where deposits made by the glaciers that invaded from the northeast were overlapped by deposits made by the glaciers from the northwest; it contains the area of southernmost advance of continental glaciers in the northern hemisphere (37°35′ N. latitude, in Johnson County); it is where the outwash drainageways from the northeast, north, and northwest converged on their way to the Gulf of Mexico; and it records the largest number of individual advances of continental glaciers. It is also part of the Upper Mississippi Valley region where early research revealed a record of multiple episodes of glaciation. These factors contribute not only to the complexities of classification, but also emphasize the necessity of an adequate scheme of classification for Illinois.

Since the 1870's, glacial geology has been considered as being separate from bedrock stratigraphy because, first, these deposits are at the surface, retain many of the primary depositional land forms (pl. 1), and in the north-central states were largely the result of continental glaciation; and second, these near-surface deposits were viewed as being of largely academic interest rather than of practical or applied value. Although the first of these two reasons may still be valid, the second clearly is not. The surficial deposits now are of prime interest in environmental problems and must be treated in a standard, practical stratigraphic framework.

Recent codes of stratigraphic practice (Willman, Swann, and Frye, 1958; A.C.S.N., 1961) specify that Pleistocene deposits be classified by the same principles as all older parts of the rock column. Independent systems of classification may be recognized for the surficial deposits, just as for the other rocks of the state. Four of the classification schemes are applicable —rock stratigraphy, which is a classification of the deposits on the basis of their readily observable lithology and is of major value to applied geology; soil stratigraphy, which is concerned with the buried soils and is of primary value for correlation and for reconstruction of paleoecology; morphostratigraphy, which is mainly involved with rock units related to moraines and the history of glacial pulsations; and time stratigraphy, which establishes time equivalency of stratigraphic units throughout the state and with adjacent regions. The units in each of these four classification systems recognized in Illinois are shown in fig. 1.

Acknowledgments — Many members of the Illinois State Geological Survey staff have contributed to this report. The X-ray analyses were made by H. D. Glass; matrix textural analyses were made under the supervision of W. A. White; and assistance in the compilation of the radiocarbon table was given by J. P. Kempton and S. M. Kim. During September 1969, a field conference to review the classification presented here was attended by R. E. Bergstrom, Charles Collinson, P. B. DuMontelle, D. L. Gross, N. C. Hester, M. E. Hopkins, A. M. Jacobs, W. Hilton Johnson, J. P. Kempton, Jean Larsen, J. A. Lineback, M. R. McComas, and J. A. Simon. We extend our thanks for helpful comments to them, and to Elwood Atherton and H. D. Glass.

GENERAL SETTING OF ILLINOIS PLEISTOCENE

Sub-Pleistocene Areal Geology

As much as half the material in the tills of Illinois has been transported less than 100 miles from its bedrock source. The character and distribution of the bedrock formations (fig. 2), therefore, is important in the studies of the composition and sources of the drift.

The major bedrock units in Illinois that contributed notable quantities of rock to the Pleistocene deposits are (1) Silurian dolomite in the northeast and in a small part of the glaciated area in the northwest; (2) Ordovician (mostly Galena-Platteville) dolomite in much of the central northern part of the state; (3) Ordovician (Maquoketa) shale in belts between the Silurian and Ordovician dolomites; (4) Mississippian limestones with minor amounts of shale and sandstone in the western part of the state; and (5) Pennsylvanian rocks consisting of shale (50 percent), sandstone and siltstone (40 percent), limestone, coal, and other minor constituents (10 percent) throughout the central part of the state. The Silurian dolomites are primarily responsible for the dominance of dolomite over calcite in Lake Michigan Lobe drift. Although Pennsylvanian rocks are abundant in the drift south of the Silurian escarpment, the Pennsylvanian contributed little limestone, and dolomite dominates the carbonates to the southern limit of the lobe.

Many rocks in the drift of Illinois came from the Precambrian outcrop area of Canada and the Lake Superior region. A relatively high percentage of garnet characterizes the heavy minerals in the drift from the Labradorean center that was carried to Illinois by the Erie Lobe. More nearly equal amounts of garnet and epidote characterize Lake Michigan Lobe drift, which came from the western part of the Labradorean center or from the Hudson Bay area, whereas there is more epidote than garnet in the drift from the Keewatin center west of Hudson Bay.

Many distinctive Precambrian rock types in the drift have been related to specific sources, such as the jasper conglomerate from the Lorraine Quartzite north of Lake Huron, which occurs in Lake Michigan Lobe drift. Purple and pink quartzite (Baraboo and Sioux) distinguishes drifts and gravels from the Upper Mississippi and Missouri Valleys. Jasper, agate, tillite, greenstone, and other distinctive rock types are common in the gravels from the Lake Superior Region.

Major additions to the drift also came from Ordovician, Silurian, and Devonian limestones of the northern parts of Indiana and Ohio and from southern Ontario, giving Erie Lobe drift in Illinois more calcite than dolomite. The dark gray to black Devonian and Mississippian shales of the Lake Michigan Basin are conspicuous in Lake Michigan Lobe drift and account for the dominance of illite in the clay minerals and the local abundance ot spores in the matrix of the tills. Mississippian to Cretaceous limestones of the Missouri Valley account for the higher calcite than dolomite content in drift from the Keewatin center. Cretaceous shales make montmorillonite the dominant clay mineral in till, outwash, and loess derived from the Keewatin center.

At the beginning of the Pleistocene, the distribution of bedrock formations in Illinois differed greatly from the present areal geology (fig. 2). Glacial erosion significantly lowered the bedrock surface, and rivers and streams extensively dissected it, particularly during early Pleistocene time. The depth of glacial erosion is uncertain, but the average thickness of drift in the glaciated area is in the order of 100 feet (fig. 3). Perhaps another 100 feet of bedrock was ground by the glaciers to sand, silt, and clay that was carried by the major rivers to the Mississippi River delta, was blown by the wind to form the widespread loess deposits, or remained in the alluvial valleys. The northeastern part of the state was repeatedly glaciated and probably the most deeply eroded. In the marginal areas

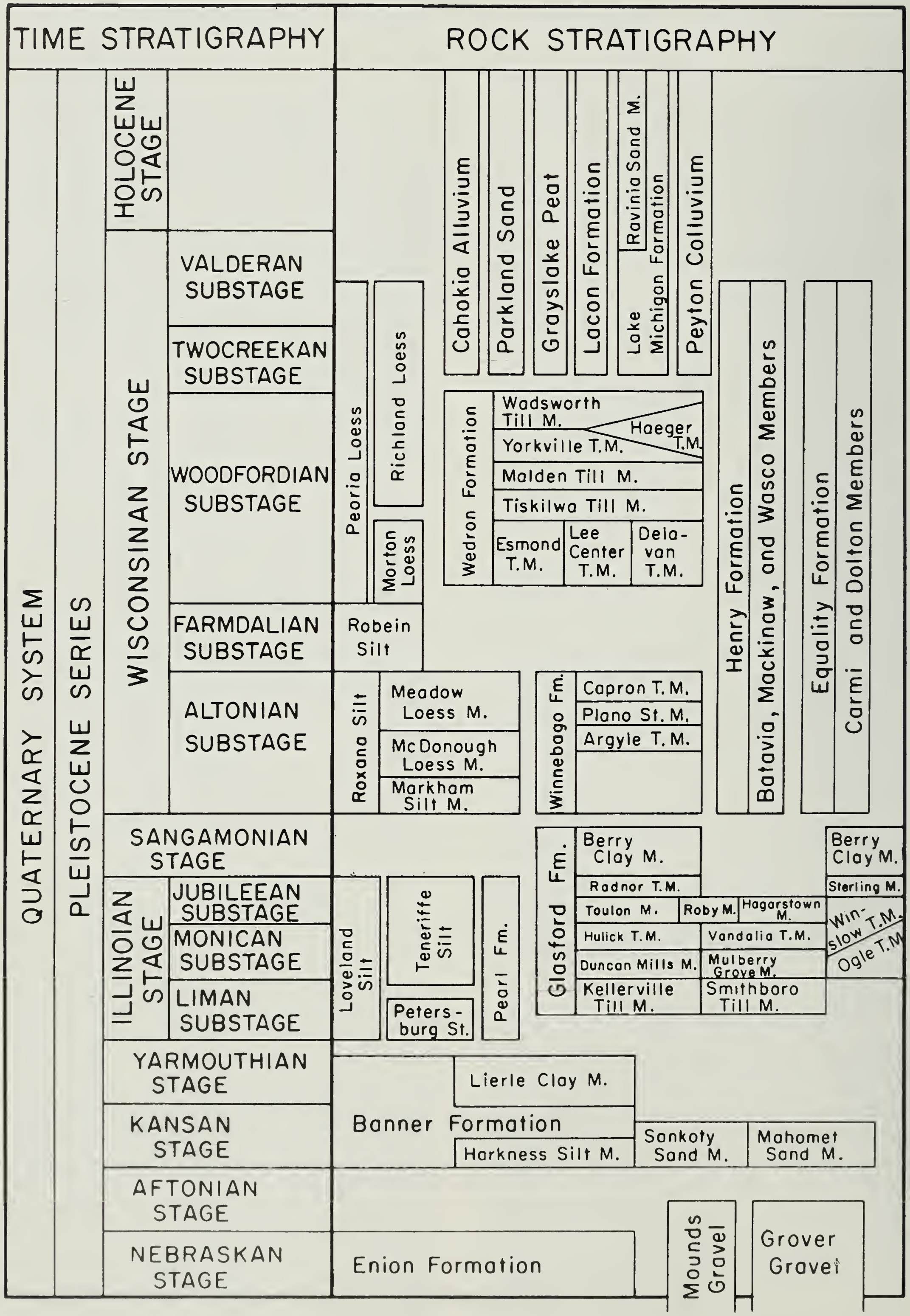


Fig. 1 — Stratigraphic classifications

SOIL STRATIGRAPHY	MORPHOSTRATIGRAPHY		
Modern Soil			
	Lake Barder Drifts		
	Zian City D.		
	Highland Park D.		
	Blodgett D.		
	Deerfield D.		
	Park Ridge D.		
	Tinley D.		
	Valparaisa Drifts		
	Palatine D.		
	Clarendan D.		
	Fox Lake D.		
	Raselle D.		
	Westmant D.		
	Keeneyville D.		
	Cary D.		
Jules Soil	Wheatan D.		Iraquais D.
	West Chicago D.		
	Manhattan D.		
	Wiltan Center D.		
	Rackdale D.		
	St. Anne D.		
Farmdale Soil	Minaoka D.		
	Marseilles Drifts		
	Ransam D.	Barlina D.	Gilman D.
	Norway D.	Huntley D.	
	Cullom D.	St. Charles D.	
	Farm Ridge D.	Gilberts D.	Chatswarth D.
Pleasant Grove Soil	Mendata D.	Elburn D.	
	Arlingtan D.	Strawn D.	Ellis D.
Chapin Soil	Shabbana D.	Minank D.	Paxtan D.
	Paw Paw D.	Mt. Palatine D.	
	La Moille D.	Varna D.	
Sangamon Soil	Theiss D.	El Paso D.	
	Van Orin D.	Fletchers D.	
	Daver D.	Eureka D.	Illiana Drifts
	Arispie D.	Normal D.	Giffard D.
	Bloamingtan Drifts		Newtawn D.
	Marenga D.	Metamora D.	Urbana D.
	Providence D.	Washington D.	Rantoul D.
Pike Soil	Buda D.	Kings Mill D.	Champaign D.
	Sheffield D.		Ridge Farm D.
	Shaws D.		Hildreth D.
			West Ridge D.
Yarmouth Soil			Pesotum D.
		Shirley D.	Arcala D.
		Le Ray D.	Cerra Garda D.
		Heywarth D.	Turpin D.
			Shelbyville Drifts
	Harrisville D.		Paris D.
Afton Soil	Temperance Hill D.		Nevins D.
	Atkinsan D.		Westfield D.
	Alluvial terraces are informally named in local areas		

of the Pleistocene deposits of Illinois.

of glaciation the depth of glacial erosion was generally slight.

The preservation of Devonian, Mississippian, and Pennsylvanian rocks in fault blocks, crevice fillings, and outliers indicates that these rocks formerly covered the area of northern Illinois where Cambrian, Ordovician, and Silurian rocks now form the bedrock surface (fig. 2). The sub-Middle Devonian, sub-Pennsylvanian, and sub-Cretaceous unconformities probably extended not far above the present bedrock surface. It is improbable that strata above one or more of these unconformities entirely covered the older formations on the pre-Pleistocene surface, but erosional lowering of the surface 100 feet or more could have stripped some of the younger formations from broad areas.

If the major rivers in Illinois at the beginning of Pleistocene time were not deeply entrenched in the bedrock surface and were moved to new positions determined largely by glacial margins, many formations now exposed along the valleys were deeply buried then, and the geologic map of that time differed greatly from the present geologic map.

Bedrock Surface

The topography of the bedrock surface in Illinois (fig. 4) generally has been interpreted as pre-Pleistocene and commonly referred to as "the preglacial surface" (Leverett, 1899a; Horberg, 1946b, 1950a; most reports prior to 1960). Horberg (1950a) interpreted the bedrock surface as largely the product of Tertiary erosional cycles and recognized, at successively lower levels, the Dodgeville, Lancaster, and Central Illinois Peneplains. He considered a lower surface, the Havana Strath, and the major part of the inner deep valley system as pre-Nebraskan but not necessarily pre-Pleistocene. In some early reports, "preglacial" means before the first glaciation of the area.

One of the most controversial problems of the Illinois Pleistocene has been the age of the deep bedrock valleys, some of them now occupied by major rivers and only partially filled by glacial drift, and others entirely filled and their presence not evident in the present topography. Intimately related to this problem is the age of the brown chert gravels that are widely scattered throughout the Mississippi Valley north of the Ozarks (Grover Gravel in Illinois). Chert gravels are absent on the higher parts of the Ozarks along the Mississippi Valley (Shawnee Hills in Illinois) but are present in the Mississippi Embayment region where they form a widespread but thin deposit (Mounds Gravel in Illinois) that truncates Cretaceous and Tertiary formations. Around the margins of the embayment the gravel overlaps onto Paleozoic rocks.

No paleontological evidence for the age of the gravels has been found in or immediately adjacent to Illinois. Stratigraphically the gravels are Cretaceous or younger in the Upper Mississippi Valley, Eocene or younger in southern Illinois, and Pliocene or younger in Mississippi. As gravel with similar composition occurs in the Cretaceous in the Upper Mississippi Valley, reworking may have produced deposits ranging in age from Cretaceous to Pleistocene, but, for the majority of the deposits, Pliocene is the oldest age consistent with the regional relations.

The gravels occur on the uppermost bedrock surface and must have been deposited before that surface was deeply eroded. As the deep valleys contain drift of Kansan age, the deposition of the gravels and the erosion of the deep valleys occurred in the interval between middle or late Pliocene and Kansan time.

If the gravels are early Pleistocene in age, then the deep dissection of the valleys is the result of Pleistocene erosion. If they are equivalent in age to type Nebraskan, the valley incision is post-Nebraskan and pre-Kansan. If, however, they represent Pleistocene deposition on the erosional surface before Nebraskan glaciation, the valley incision could be Pleistocene but pre-Nebraskan in age. If, by definition, Nebraskan includes, or is extended to include, all such gravels, then these events could be intra-Nebraskan.

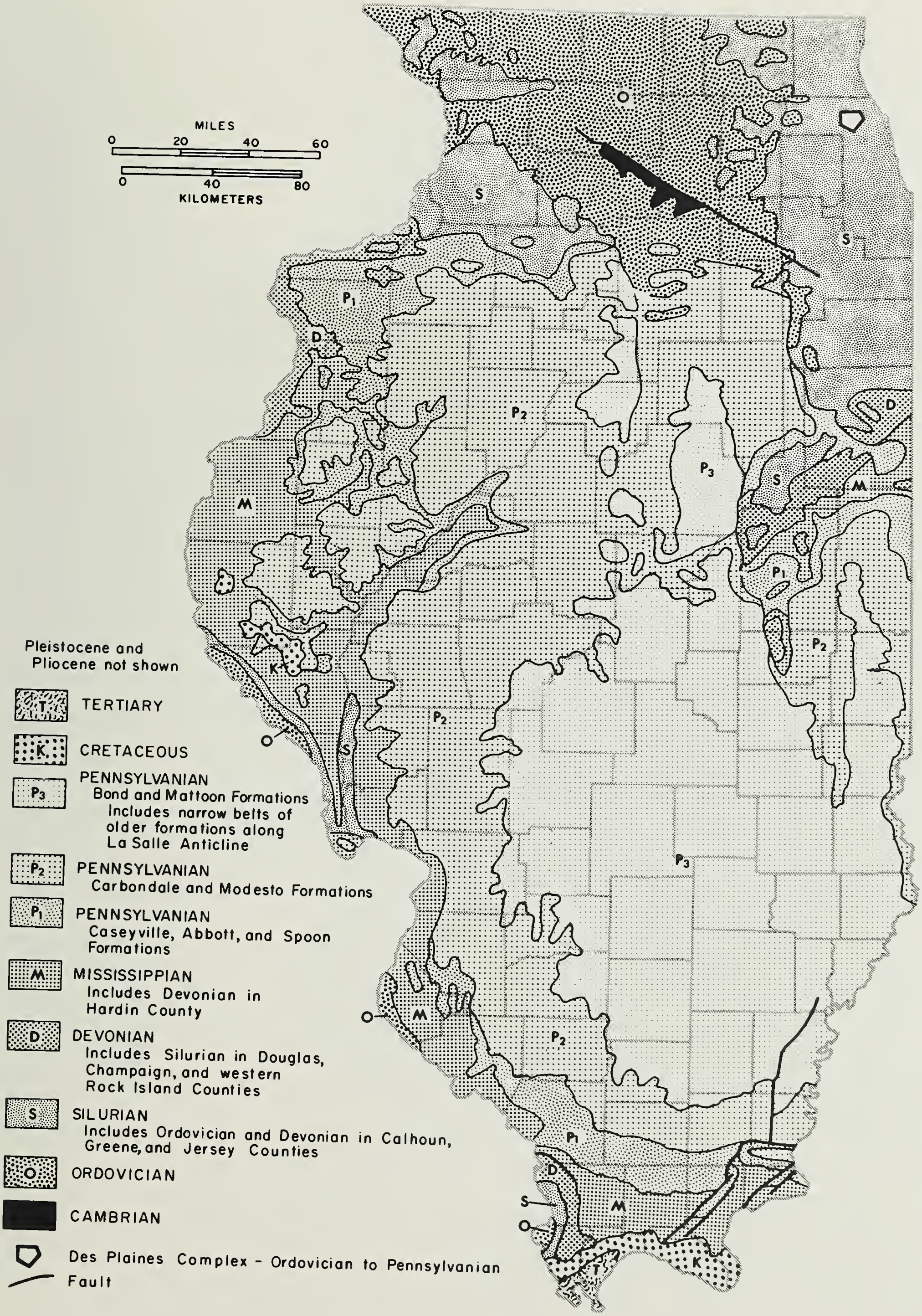


Fig. 2 — Generalized areal geology of the bedrock surface of Illinois (see Willman et al., 1967, for more detailed mapping).

If the gravels are Pliocene in age, the deep erosion can be either late Pliocene, pre-Nebraskan Pleistocene, or post-Nebraskan and pre-Kansan. As above, the middle alternative involves a problem of definition, but the three possibilities exist.

Although a full discussion of the alternatives cannot be given here, the problem is important to an understanding of the setting of the Illinois Pleistocene, and some of the principal relations and the major interpretations must be considered.

Age of Deep Valleys

The depth of erosion of the valleys at the beginning of Pleistocene time in Illinois is difficult to demonstrate conclusively because deposits of the Nebraskan glaciation are scarce. Some evidence favors shallow entrenchment of the rivers, but other evidence suggests that the rivers were deeply entrenched, perhaps to their maximum depths (fig. 4), at the beginning of the Pleistocene.

Evidence Favoring Shallow Entrenchment

The interpretation that the major rivers were not deeply entrenched before Nebraskan glaciation was developed by Trowbridge (1921) for the Upper Mississippi Valley. Present evidence favoring shallow entrenchment consists of the following:

(a) Most of the deep valleys lie near the margins of early glaciations. If their positions are determined by the glaciers, the entire entrenchment is Pleistocene.

(b) Other deep valleys not clearly related to glacial margins and out of adjustment to stratigraphy and regional slope are related to the blocking of northward flowing drainage by the early Pleistocene glaciers. For example, the Ticona Valley in Putnam and La Salle Counties resulted when drainage previously flowing northeastward was diverted westward across the La Salle Anticline (Willman, 1940). The Mahomet Valley in central Illinois, rather than being preglacial (Horberg, 1945, 1950a) also is more logically the outcome of glacial blocking of the northward flowing Teays drainage.

(c) The deposits identified as Nebraskan in age are in relatively low parts of upland areas but are not deeply entrenched in the bedrock surface. The Nebraskan outwash gravel in a small tributary to the Mississippi River, only a quarter of a mile from the bluffs (Zion Church Section, table 6), is more than 50 feet above the present Mississippi floodplain and more than 250 feet above the bedrock floor of the valley. This is less than 50 feet below the bedrock surface in the bluffs, but is 100 to 150 feet lower than the bedrock surface 2 to 3 miles east of the bluffs.

(d) Kansan age deposits are well preserved in many of the extensive buried valley systems, clearly indicating that such valleys are older than the Kansan glaciation. The absence of weathered glacial drift beneath the Kansan deposits in the valleys, the most favorable places for their preservation, suggests that the valleys were not there during Nebraskan glaciation.

(e) The presence of outwash gravel on the upland surface in the Driftless Area of northwestern Illinois (Willman and Frye, 1969), at the margin of the area of Nebraskan glaciation not far west in Iowa (Trowbridge, 1966), strongly suggests that the Mississippi River was not there when Nebraskan ice reached the present position of the Mississippi Valley.

(f) In the Missouri Valley and the Great Plains, deposits of Nebraskan age are at relatively high levels and were deeply eroded before Kansan glaciation (Frye and Leonard, 1952). In the Rocky Mountains the older glacial deposits also occur at high levels and the valleys were greatly deepened before the younger glaciations (Richmond, 1965).

If the valleys were shallowly entrenched in a late Tertiary surface that was relatively flat (Frye, 1963), then the present topography resulting from dissection of this surface is almost entirely Pleistocene in age, and erosion may have eliminated even traces of the pre-Pleistocene valleys, particularly in the areas covered by glaciers.

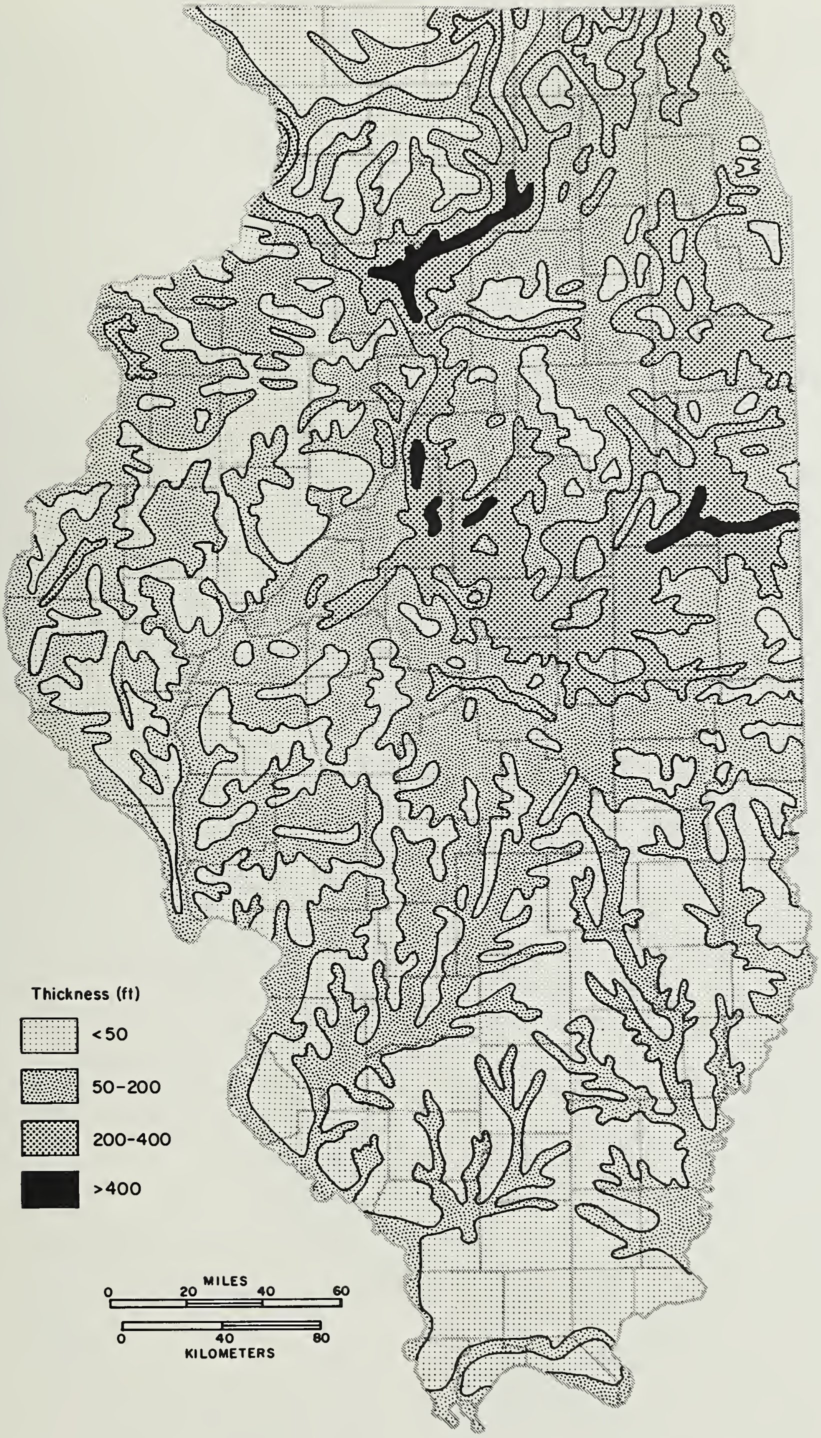


Fig. 3 — Thickness of Pleistocene deposits of Illinois (after Piskin and Bergstrom, 1967).

Evidence Favoring Deep Entrenchment

Interpretation of the present bedrock surface, in particular the deep valleys, as preglacial is inherited from early observations that the valleys were there before the glacial deposits. The task of establishing a pre-Pleistocene age for the valleys is handicapped, like the opposing interpretation, by the scarcity of earliest Pleistocene deposits.

Horberg (1950a) thought that major segments of the bedrock valleys were adjusted to structure and stratigraphy and therefore not related to glaciation, but the exceptions are notable, and in such flat-lying sediments the evidence is not convincing. He interpreted the Sankoty and Mahomet Sands in the deep part of the valleys as Nebraskan or preglacial in age and the entrenchment of the valleys, therefore, as pre-Nebraskan.

Flint (1941) concluded that the position of the Mississippi Valley on the eastern flank of the Ozarks is antecedent to a late Tertiary uplift of the Ozark Dome and that it could not have been determined by the margin of an ice sheet because (1) the valleys on the west side of the ice sheet would then have been ponded and alluviated, but no such deposits have been found; (2) a capacious parallel valley now filled with drift should be present east of the Mississippi Valley, but it does not exist; and (3) valleys flowing eastward down the slope of the Ozarks should have continuations east of the valley, but they do not. These interpretations assumed the presence of a deep valley system when the earliest glacier arrived, whereas such negative evidence may better support the interpretation that the Ozark Peneplain was relatively undissected. The small area of till on the west bluffs of the Mississippi River at Ste. Genevieve noted by Weller and St. Clair (1928) and Flint (1941) does not require preglacial erosion to that depth as it could have been deposited by the Illinoian glacier in a brief invasion of the valley.

Trowbridge (1959, 1966) interpreted the Mississippi Valley in northeastern Iowa to be post-Nebraskan because Nebraskan drift occurs only on an upland surface, whereas Kansan drift fills valleys cut into the surface. However, he concluded that the major bedrock valley through central and southeastern Iowa is pre-Nebraskan because of the presence of possible Nebraskan drift in the valley. If the Nebraskan age of the drift in the valley is established, it would indicate that the present Mississippi Valley below Muscatine is older than the type Nebraskan.

Age of Chert Gravels

The age of the deep entrenchment of the valleys is intimately related to the age and origin of the chert gravels on the upland surfaces. These deposits, previously called Lafayette gravel or referred to various named terraces, are here assigned to two formations — Grover Gravel for the deposits north of the Shawnee Hills, and Mounds Gravel for the deposits in the embayment area in southern Illinois.

Grover Gravel

The Grover Gravel rests on upland surfaces, generally 300 to 400 feet above the bedrock floor of major valleys nearby. The gravel is dominantly light brown chert with quartz pebbles in a matrix of quartz sand, but it contains pebbles of purple quartzite, agate, and jasper almost certainly derived from the Lake Superior region. Some of the deposits contain a few relatively fresh igneous and metamorphic pebbles, others only pebbles of clay that appear to be weathered igneous rocks, but many contain no igneous pebbles and no metamorphic pebbles other than the quartzites.

Stratigraphically the gravel is bounded by Kansan till above and Cretaceous clays below, but generally the gravel rests on Paleozoic bedrock and is overlain by the Illinoian Loveland Silt, or locally by Illinoian till. The gravel is similar in composition to the Hadley Gravel at the base of the Cretaceous Baylis Formation in western Illinois (Frye, Willman, and Glass, 1964). Consequently, it is not improbable that isolated, small, and poorly exposed deposits may range in age from Cretaceous to early Pleistocene.

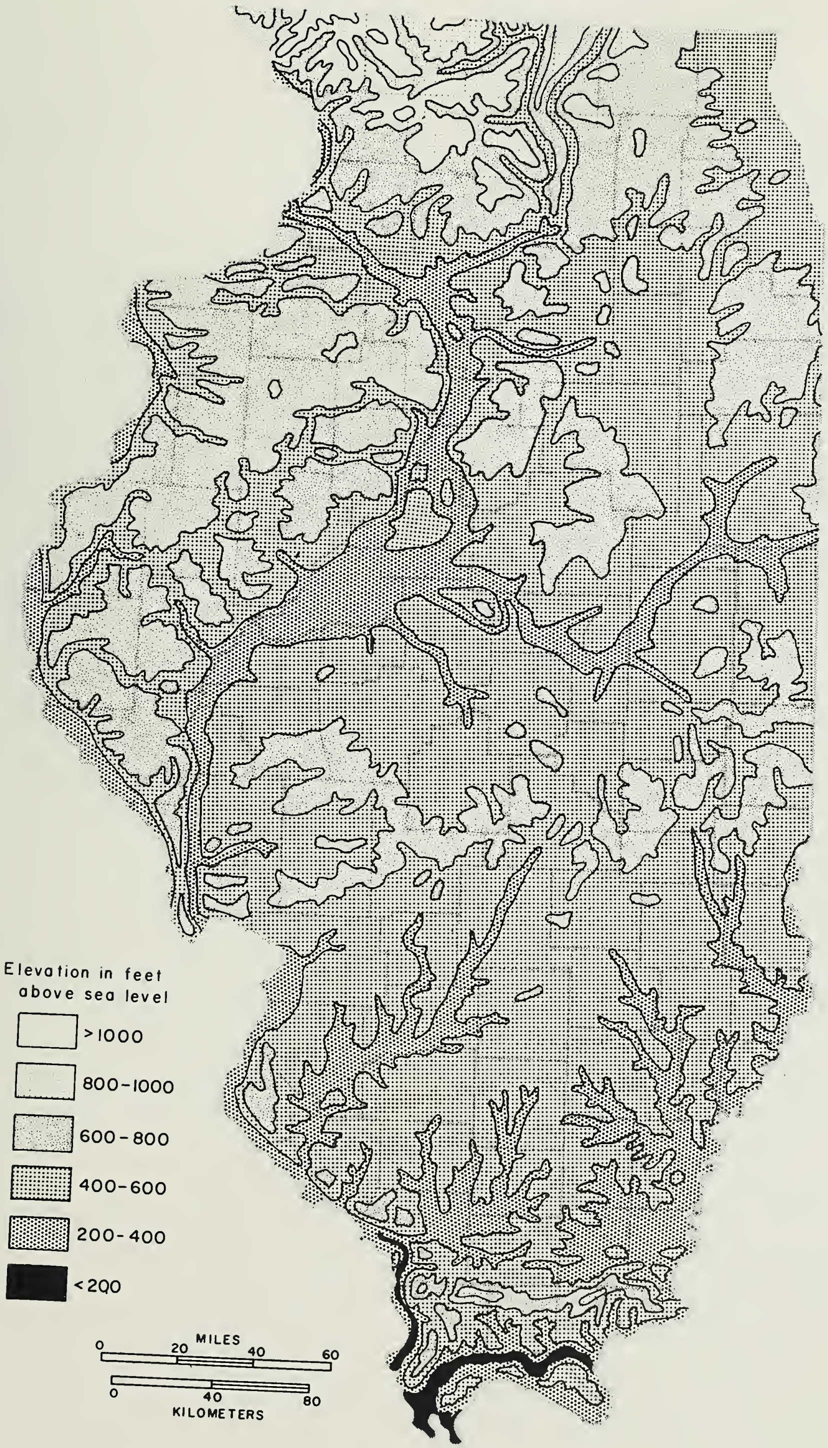


Fig. 4 — Topography of the bedrock surface of Illinois (after Horberg, 1950, and others).

In the type region in Missouri and in Calhoun County, Illinois, the gravel contains boulders of quartzite as much as 2 feet thick, and these are difficult to account for except by glacial transportation. The nearest source of the quartzites is more than 300 miles north in central Wisconsin (Baraboo Quartzite), or more than 400 miles northwest in northwestern Iowa (Sioux Quartzite). Glacial transportation has been rejected in most discussions of their origin because of the assumption that if the deep valleys are preglacial the gravels must be Tertiary (Salisbury, 1892; Leighton and Willman, 1949; Rubey, 1952; Potter, 1955b). Glacial transportation was favored by Willman and Frye (1958).

Rubey (1952) noted that the gravel appears to be displaced over 100 feet by movement along the Cap au Grès Faulted Flexure in Calhoun County, and he suggested a late Miocene age for the gravel.

The Grover Gravel is dominantly siliceous and lacks the characteristic highly varied rock and mineral composition of the typical Nebraskan and younger glacial deposits. If the Grover Gravel is glacial outwash, it must be derived from a glacier that was loaded with Cretaceous or Tertiary gravels, which may then have been widely present on the surface.

The possibility that deposits of Grover Gravel are the only remnants, perhaps reworked remnants, of a glaciation older than type Nebraskan may be favored by their exceptionally high topographic position, as well as their different composition. By definition, the type Nebraskan includes glacial deposits that are younger than the Pliocene Ogallala Formation and are overlain by the Afton Soil and Kansan drift. There are two episodes of glaciation within the Nebraskan in the type region, both filling shallow channels in the bedrock surface (Reed and Dreeszen, 1965). There is no evidence of Pliocene glaciation in that region. However, recent studies in the Cordilleran region, where glacial tills and tillites are interbedded with lava flows dated by the potassium-argon method, indicate repeated mountain glaciation, the oldest about 10 million years ago, that may extend back into the Miocene (Denton and Armstrong, 1969).

If the Grover Gravel is older than type Nebraskan, it could be assigned either to an earlier Pleistocene glaciation or to the Pliocene, and, as we lack basis for a choice, we at present refer the gravel to a Pliocene-Pleistocene age.

Mounds Gravel

The Mounds Gravel in extreme southern Illinois is more precisely dated, for it clearly truncates the Eocene Wilcox Formation there, and, farther south, it truncates Oligocene, Miocene, and early Pliocene marine formations. Like the Grover, it is overlain by the Illinoian Loveland Silt, except for some deposits at low levels that may be post-Illinoian reworked gravel.

The Mounds Gravel occurs at elevations from about 380 to 600 feet, whereas gravel with compositions of the typical glacial outwash in the Upper Mississippi, Wabash, and Ohio Valleys does not occur above the level of Wisconsinan terraces—a maximum of 360 feet—or about 40 feet above the present floodplains of the Mississippi and Ohio Rivers where they cut through the Mounds Gravel. These relations have been interpreted to indicate that the Mounds Gravel is (a) entirely Pliocene in age (Salisbury, 1891a; Leighton and Willman, 1949; Potter, 1955b; and others), (b) that the Mississippi and Ohio Valleys were eroded nearly to present depths by the beginning of Pleistocene glaciation, and (c) that Nebraskan, Kansan, and Illinoian outwash passed through the valleys at levels below the level of Wisconsinan aggradation.

Fisk (1938, 1944) interpreted the gravels as Pleistocene in age because they truncated Pliocene strata and because they were the logical product of the change in conditions in the Upper Mississippi Valley that resulted from glaciation. He differentiated the chert gravels into deposits on three terraces (Williana, Bentley, and Montgomery), relating them to cycles of interglacial deposition during elevated sea level, erosion during the lowered sea level of the glacial stages, and separation of the

terraces because of continuous uplift during the Pleistocene. A fourth terrace (Prairie), the lowest, unquestionably contains glacial outwash.

Potter (1955b) interpreted the chert gravel as alluvial fans deposited by the Tennessee and Mississippi Rivers where they emerged from Paleozoic uplands onto the Mississippi Embayment lowland. He combined the deposits on the upper two terraces into one episode of deposition in the Pliocene. He also included in the Pliocene the third terrace, which has relatively limited distribution. The uniformity of the Mounds Gravel, as brought out by Potter (1955a, 1955b), is too great to encourage an interpretation that the gravels are partly Pliocene and partly Pleistocene. In fact, the validity of the terrace differentiation in southern Illinois is open to question. The surface of the gravel, with a few gaps, slopes from 600 feet south of the east end of Cache Valley to 380 feet at the west end. If this is the slope of the Tennessee River alluvial fan, it embraces the entire range in elevation of the Mounds Gravel. Furthermore, the abrupt rise of the gravel onto the Paleozoic upland near the Mississippi Valley, its sharp termination, and local faulting of the gravel suggest that the elevation change in that area may be in part the result of postgravel deformation.

The Mounds Gravel contains no igneous or metamorphic rocks, other than quartzite. The associated sands have the same heavy minerals as the underlying Cretaceous and Tertiary sediments, minerals that are characteristic of an eastern source in the Piedmont region. However, Potter (1955a) showed that the gravels from the present Mississippi Valley near Thebes, Alexander County, and southwestward in Crowleys Ridge in Missouri differed in mineral content and rounding of quartz grains and suggested that they were derived from the Upper Mississippi Valley. As the gravels west of the Mississippi River also contain the purple quartzite, agate, and jasper that characterize the Grover Gravel but are lacking in the deposits to the east, an Upper Mississippi Valley source is indicated. However, the abundance of dark brown chert, kyanite, and staurolite suggests considerable mixing with the gravels from the eastern source.

The magnitude of the unconformity between the Mounds Gravel and the demonstrably Pleistocene deposits is great, which favors a pre-Pleistocene age. The oldest unquestionably Pleistocene deposits are not more than 40 feet above the modern floodplain and are Wisconsinan (Woodfordian) in age. As there is no trace of older outwash at higher levels, either in the main valley or in the tributaries northward to the St. Louis region, it is assumed that the levels of pre-Wisconsinan valley trains were lower than the present floodplain.

Both the Ancient Mississippi and Ancient Ohio Valleys turn sharply westward where they encounter the Mounds Gravel, the deep channel of the Mississippi turning into the broad, abandoned valley west from Cape Girardeau, and the Ohio channel along the abandoned Cache Valley. At the margin of the gravels the Mississippi and Ohio Valleys were cut at least 400 feet deep, largely through Paleozoic bedrock, after deposition of the Mounds Gravel. This adjustment to stratigraphy and structure suggests a major hiatus between the gravel and the incision of the valley and favors a Pliocene age.

If the pre-Pleistocene rivers were only slightly entrenched in a relatively flat surface and the drainage were diverted across the Shawnee Hills when the earliest glacier reached the Ozarks, the resulting river would have had a steep gradient, probably more than 50 feet per mile, which could have initiated the erosion cycle that produced the deep incision. This would at least leave the door open for the Mounds Gravel to be earliest Pleistocene but possibly older than the type Nebraskan.

An intermediate interpretation would have the drainage of the Mississippi Valley region at the beginning of the Pleistocene following the channel along which the Mounds Gravel had been transported to the head of the embayment region. Slight uplift of the Ozarks would remove traces of that valley, and the river would

become deeply entrenched because of the increased gradient and the influx of glacial meltwater.

Because the Mounds Gravel westward from the Mississippi River, including gravel at the highest level (elevation about 600 feet near Commerce, Missouri), was at least in part derived from the Upper Mississippi Valley and has similarities to the Grover Gravel, the two formations may be contemporaneous. They also have the same uncertain age. Consequently, the Mounds, like the Grover, is assigned to a Pliocene-Pleistocene age.

Early Pleistocene Drainage

If the present valleys of the bedrock surface owe their positions largely to glaciation, they furnish slight information about the general topography, the position of the valleys, and the direction of drainage on the pre-Pleistocene surface. Furthermore, high-level gravels (Willman and Frye, 1969) indicate that the deep dissection and mature topography of the Driftless Area of northwestern Illinois is a product of Pleistocene erosion and not a preserved example of the preglacial topography, as it is frequently interpreted. The dissection of the Driftless Area appears to be largely Kansan and later.

The major streams north of the Shawnee Hills in the extreme southern part of Illinois may have flowed northward until blocked by the growth of glaciers from the Canadian centers. The position of such valleys is not indicated in the present bedrock topography. Being shallow, they would have been removed by glacial erosion and by erosion of streams in new positions determined by glacial diversion and isostatic change in direction of land slope. The deep basin of Lake Michigan, although in major part the result of repeated glacial erosion, probably was begun by a northward flowing river that became established in the northward trending outcrop belt of relatively soft Devonian and Mississippian shales east of the resistant Silurian dolomite. The river probably joined the northward flowing Teays River, and its tributaries may have covered most of Illinois.

Many reports describe the Teays Valley as turning westward in central Ohio, crossing northern Indiana, and joining the Ancient Mississippi Valley in central Illinois. For a preglacial valley, such a course would be out of adjustment with structure, as it would have crossed the Cincinnati Arch, and it seems more probable that the abrupt westward turn of the Teays Valley and its long westward segment is the result of glacial diversion, perhaps several diversions. No deposits definitely identified as Nebraskan have been found within the valley.

Effect of Isostatic Movements

The response of the earth's crust to the loading and subsequent unloading by the Pleistocene glaciers was to yield slowly, subsiding as the glaciers' weight increased and rebounding after the glaciers' weight was diminished and finally removed. As the rate of build-up and of removal of the glaciers was much faster than the capacity of the earth's crust to yield isostatically, the shape of the surface continued to change slowly long after the glaciers had disappeared. This phenomenon of glacial isostatic depression and rebound has been well documented and accepted for many years. However, crustal upwarping beyond the limit of the glacier, called forebulge, has been proposed only in recent years as a significant factor in Pleistocene geology (Frye, 1963; McGinnis, 1968). This concept holds that as the crust was being depressed by the increasing load of the glacial ice a compensating upwarp developed around the margin of the area of glacial loading. Also, as the central area of glacial depression rebounded after the dissipation of ice, the elevated forebulge subsided. This system was dynamic—the area of depression expanded as the area of glacial ice expanded, and the position of the forebulge migrated in front of the advancing glacier. As crustal response lagged, a rapidly advancing glacier may have been advancing up the inner slope of its forebulge. Also, when glacial retreat and dissipation were rapid, the crustal elevation in the depressed area and subsidence in the elevated forebulge area con-

tinued long after the disappearance of the glacier.

The influence of these crustal bendings on Pleistocene drainage development, erosion, and deposition must have been great. It caused bedrock gradients of very different magnitudes than those observed today, and in some places a reversal of bedrock gradient. It seems certain that it is the mechanism that caused the bedrock entrenchment of such valleys as the Ancient Mississippi through segments hundreds of miles long that now display no gradient and locally have reversed gradients. The forebulge also may have accounted for the temporary ponding and accumulation of lacustrine sediments. Although direct measurements of isostatic rebound have been made only for the last glacial episode north of Illinois, the phenomenon may have had an important effect on drainage changes and sediments associated with each of the glacial episodes.

Glacial History

Pleistocene stratigraphy and classification in Illinois are based on concepts and interpretations of the glacial history that are the outgrowth of studies by many people during the last century. An exhaustive discussion of the glacial history cannot be attempted here, but the following is a summary of some of the major events and controversial problems that are particularly important as a setting for the stratigraphic classification.

Glaciers invaded Illinois from three directions (fig. 5). During the Nebraskan and Kansan glaciations, glaciers from the Keewatin center of radiation entered Illinois from the west and northwest. During Kansan, Illinoian, and Woodfordian glaciations, the Erie Lobe and probably the Saginaw Lobe glaciers from the Labradorean center entered Illinois from the east and northeast. During Illinoian, Altonian, and Woodfordian times, glaciers of the Lake Michigan and Green Bay Lobes from the Hudson Bay region entered Illinois from a northerly direction. The ice front probably advanced and retreated more than once during each of the glacial ages, but the record is scant for the Kansan and absent for the Nebraskan.

Nebraskan Glaciation

Although the Nebraskan glacier from the Keewatin center invaded Illinois and probably covered much of the area west of the Illinois Valley, remnants of Nebraskan drift are scarce, and they are here combined in the Enion Formation. Weathered Nebraskan till has been identified at two, possibly three, localities in Fulton County (Wanless, 1955, 1957). Weathered Nebraskan outwash is present in Adams County (Frye and Willman, 1965b) and Jo Daviess County (Willman and Frye, 1969). The Fulton County deposits may represent the farthest eastward advance of the Nebraskan glacier. The deposits are near the bluffs of the Ancient Mississippi River (fig. 5), which probably had its origin as an ice marginal stream of the Nebraskan glacier.

The high-level gravel that occurs in the Driftless Area of northwestern Illinois, just east of the Mississippi Valley bluffs (Willman and Frye, 1969), is considered Nebraskan in age because its most probable source was the glacier that deposited drift west of the river, which was and is interpreted as Nebraskan in age (Trowbridge, 1966). The gravel was deposited before the Mississippi Valley was eroded, which also suggests a pre-Kansan age. Well bedded silts and clay below the gravel are probably lake deposits. As the Driftless Area north of the Silurian escarpment probably drained northward at that time, the advancing Nebraskan glacier blocked the streams and a lake covered the erosional surface on the dolomite of the Galena Group — the relatively undissected Lancaster Peneplain. The outlet of the lake may have established the Mississippi River at the site of its present deep valley through the Silurian escarpment.

Evidence for Nebraskan glaciation from the northeast is slight and largely inferential. The presence of igneous boulders on the upland surface west of the Mississippi River in Missouri, 10 to 15 miles

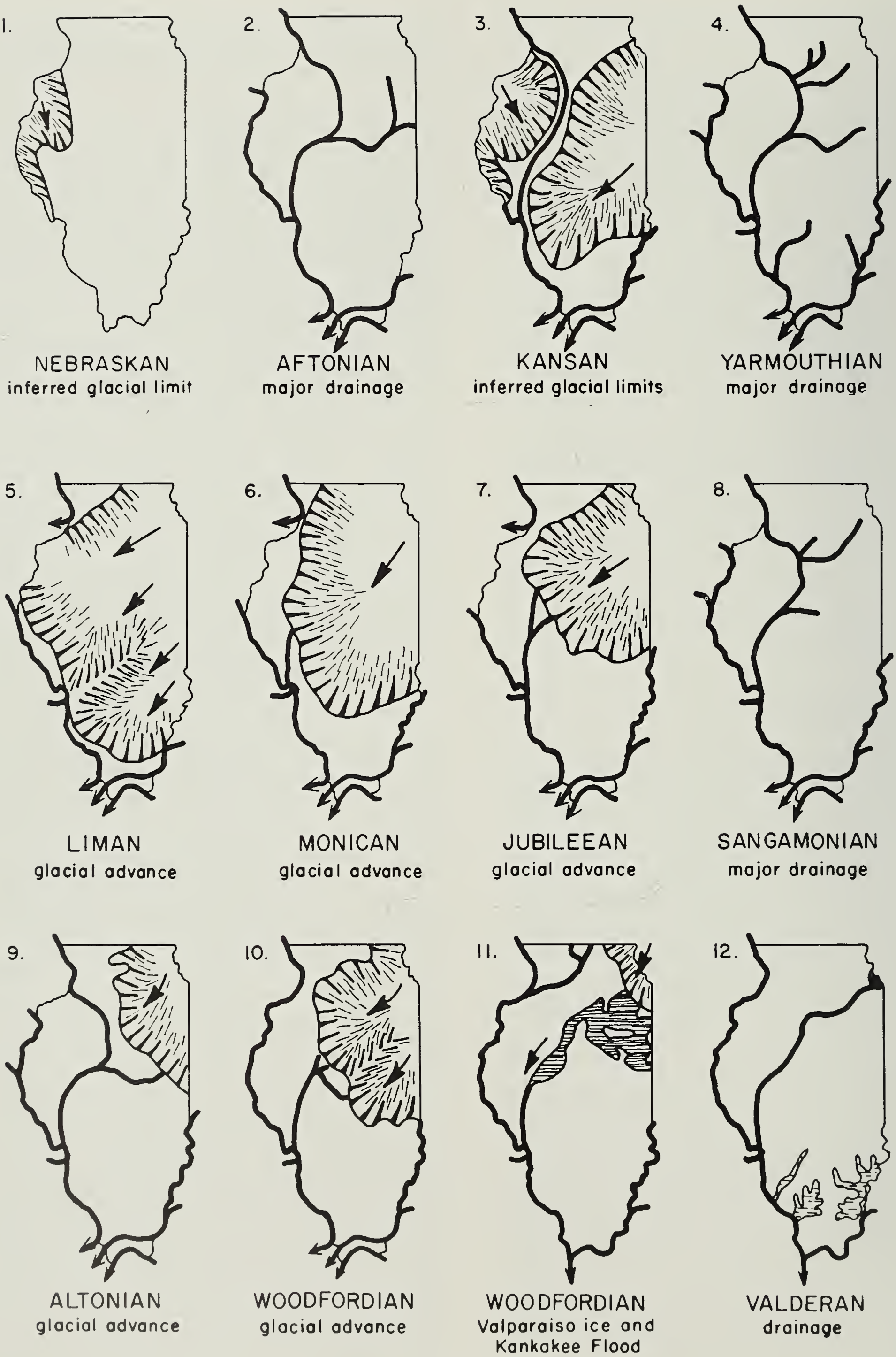


Fig. 5 — Sequence of glaciations and interglacial drainage in Illinois.

beyond the limit of Illinoian glaciation and 200 to 250 feet above the present Mississippi River, raises the possibility that Nebraskan ice from the northeast may have reached this region. The absence of till makes it improbable that the Illinoian ice advanced that far west. The presence of granite, diabase, and rhyolite (Flint, 1941) indicates that the boulders are not related to the Grover Gravel. Kansan drift is present only 20 miles north, but if the boulders are the result of Kansan glaciation, preservation of that drift in some of the valleys would be expected. If Nebraskan ice advanced onto the eastern slope of the Ozarks, it would account for diversion of drainage across the Shawnee Hills, thus establishing the Mississippi River in its present position.

Blocks of weathered till in fresh Kansan till in the Danville area in eastern Illinois were interpreted by Eveland (1952) to indicate Nebraskan glaciation in or northeast of that area, but the age of the till he called Kansan has been questioned (Ekblaw and Willman, 1955). Although the presence of Nebraskan till in the Cincinnati area was suggested by Ray and Leighton (1965), the age of the drift there also has been questioned. No definite evidence of Nebraskan glaciation from the northeast has been found, but it seems probable that in eastern North America Nebraskan ice advanced at least far enough to block northward flowing rivers. The general lack of evidence of Nebraskan glaciation is consistent with the interpretation that major dissection of the region followed that glaciation. Also, truncation by younger glaciers has been so intensive that even deposits of Illinoian age are rarely found beneath Wisconsinan drift more than 30 or 40 miles back from the Wisconsinan front.

Kansan Glaciation

By the time the Kansan glaciers advanced into Illinois, the Ancient Mississippi, Ancient Iowa, and Ancient Ohio Valleys were deeply entrenched, perhaps at their maximum depths and at least below the level of the modern floodplains. Kansan glaciers advanced from both the Keewatin and the Labradorean centers. The areas of drift are not known to overlap, but they nearly meet in west-central Illinois (fig. 5). The possible presence of western Kansan drift in Menard County east of the Illinois Valley has been suggested by Johnson (1964). The two glaciers may not have reached maximum extent at the same time. The tills have distinctive mineral compositions (Willman, Glass, and Frye, 1963), with garnet more abundant than epidote in the eastern drift and epidote more plentiful than garnet in the western drift. Illite is dominant among the clay minerals in the eastern drift and montmorillonite in the western (tables 2, 4, 5). The Kansan drift from both centers composes the Banner Formation, which is separated from the Illinoian Glasford Formation by a thick weathered zone, the Yarmouth Soil.

Western Drift — The glacier from the Keewatin (western) center extended southward down the Ancient Iowa Valley nearly to St. Louis (Rubey, 1952). It buried the Ancient Missouri Valley through northwestern Missouri and diverted the river southward many miles to its present position. The magnitude of pre-Kansan erosion is well shown at St. Charles, Missouri, by the contrast between the 2-mile wide Missouri Valley, eroded since Kansan glaciation, and the 4- to 5-mile wide Mississippi Valley, largely eroded before Kansan glaciation. The Keewatin glacier reached the present Mississippi River bluffs in Calhoun County (Rubey, 1952), which then were at least 250, and probably 350, feet high. Near the south line of Pike County the ice advanced into Illinois. The ridge of Cretaceous rocks in Pike and Adams Counties, although composed of relatively soft sediments, appears to have been adequate to divert the ice to either side, as only a single erratic boulder (which could have been transported by man) has been found on the ridge (Frye, Willman, and Glass, 1964). Elsewhere in Illinois, the Kansan glacier is not known to have extended beyond the area later covered by the Illinoian glaciers.

Eastern Drift—The Kansan glacier from the Labradorean center, the Erie Lobe, entered Illinois from an easterly direction and spread southwestward to Randolph and Franklin Counties, westward to St. Louis, and northward to La Salle County. Most of the known exposures of eastern Kansan drift are south of the margin of Wisconsinan drift (MacClintock, 1926, 1929, 1933; Leighton and Brophy, 1961; Jacobs and Lineback, 1969) and have the mineral composition of Erie Lobe drift. In a few exposures in Menard County (Johnson, 1964), the Kansan till has a higher dolomite content than is typical of Erie Lobe drift, indicating that the northern edge of the Kansan glacier may have passed over the Silurian dolomite. There is no evidence of a Lake Michigan Lobe in Kansan time, but the Kansan ice may have eroded the area which became the Lake Michigan Basin, setting the stage for the prominent lobe formed by the Illinoian glacier.

Outwash — The deep bedrock valleys (fig. 4) were partly filled with outwash from the advancing glaciers—the Sankoty Sand largely from the Keewatin glacier, and the Mahomet Sand from the Labradorean glacier. The Kansan ice modified much of the drainage and nearly filled many valleys. It blocked streams flowing eastward down the Silurian escarpment in northeastern Illinois and diverted the drainage westward, forming Hadley Valley (Horberg and Emery, 1943; Horberg and Mason, 1943). In a similar manner, eastward drainage from the high area along the crest of the La Salle Anticline was diverted westward across the structure, eroding the Ticona Valley in Grundy, La Salle, and Putnam Counties. Weathered deltaic sands beneath Illinoian drift at Wedron, La Salle County, were probably deposited in a lake before the outlet along the Ticona Valley was cut down (Willman, 1940; Willman and Payne, 1942).

Loess — The presence of boulders of pro-Kansan loess in Kansan till has been reported (Wanless, 1957) and the Harkness Silt Member may in part be loess (Frye and Willman, 1965a). Kansan loess appears to be very scarce within the glaciated area, and none has been found beneath the Loveland Silt in the numerous exposures in the unglaciated area of southern Illinois. This can be attributed to Yarmouthian erosion, but it may also reflect the narrowness of the valleys, the low level of fill in the valleys, the regimen of the glaciers, and the composition of the outwash. The Sankoty Sand, for instance, would be a poor source for loess.

Yarmouthian Interglacial Age

Following the retreat of the Kansan glacier, the deep Yarmouth Soil was developed on the Kansan drift and in many places is characterized by the accumulation of accretion-gley, the Lierle Clay Member of the Banner Formation. Although erosion of the drift may have been continuous near and in the major valleys, the great dissection of the Kansan till plain clearly follows the formation of the soil. Much of the erosion must have occurred during late Yarmouthian time or during the early phase of climate change at the beginning of the Illinoian. The contrast between the dissection of Illinoian drift and Kansan drift in adjacent areas (for example, near Mendon in Adams County) is great. The Illinoian till plain retains many depositional features, whereas the area of Kansan glaciation is so intricately eroded it does not look glaciated.

The Yarmouthian Age appears to have been very long. The average thickness of Yarmouth Soil probably is more than twice that of the Sangamon Soil. Because of the progressive decrease in the rate of deepening of a soil profile, the Yarmouthian Age may well have been three or four times longer than the Sangamonian.

Illinoian Glaciation

At the maximum of Illinoian glaciation, nearly 90 percent of Illinois was covered by ice. The Lake Michigan Lobe spreading south and west from the Lake Michigan Basin encountered the Erie Lobe that

entered the state from the east. As a result, the Erie Lobe was diverted into a more southerly course and reached, on the northern slope of the Shawnee Hills, the maximum southern extent of continental glaciation in the northern hemisphere, only 20 miles from the Mississippi Embayment region. The Lake Michigan Lobe was diverted to the west, crossed the present Mississippi Valley, and penetrated about 20 miles into Iowa along a 100-mile front.

The contact of the two lobes is considered to have occurred in the area of ridged drift in the Kaskaskia Basin and extended from Shelbyville in Shelby County to Belleville in St. Clair County (pl. 2). The origin of the ridged drift has been controversial since Leverett (1899a) interpreted the ridges as the end moraine of the glacier covering southern Illinois (the Erie Lobe). Ekblaw (1959) favored that interpretation and correlated the morainic belt with the Jacksonville Moraine of the Lake Michigan Lobe. Ball (1940), Leighton (1959), and Leighton and Brophy (1961) interpreted the ridges as crevasse deposits. Jacobs and Lineback (1969) suggested an origin in crevasses that were englacial ice-walled channels. They emphasized the prevalence of gravel in the ridges and related localization of the ridges to the buried Kaskaskia Bedrock Valley. Willman, Glass, and Frye (1963), on the basis of differences in mineral composition of the surface tills east and west of the ridged drift, interpreted the deposits as an interlobate complex marking the zone of contact of the Erie and Lake Michigan Lobes, the position supported here.

Till Plain — The Illinoian till plain is distinguished by a flatness scarcely equaled by most lake plains. The flatness is attributed to dissipation of the ice by stagnation and the leveling action of slopewash, which is indicated by the abundant accretion-gley soils. Stagnation is indicated by the preservation of oriented features related to crevasses (Leighton, 1959). Ridges represent deposition in the crevasses, and valleys result from lack of deposition or from erosion.

Moraines are present locally but are weakly developed along the outer margin of the Illinoian drift. Within the Illinoian till plain, moraines are even less prominent, are discontinuous, and correlations are uncertain. Differences in mineral composition have raised doubts about the accuracy of previous correlations of the Buffalo Hart and Jacksonville Moraines from central Illinois westward across the Illinois Valley. The Buffalo Hart and Jacksonville Moraines in western Illinois (Wanless, 1957, p. 134) are here considered to be equivalent, and, as neither is equivalent to the type Buffalo Hart or type Jacksonville, they are renamed the Table Grove Moraine (see Morphostratigraphy). The Table Grove is the most continuously traceable of the Illinoian moraines, and it apparently represents a rejuvenation and readvance of the ice. Differentiation of individual drift sheets within the Illinoian, based largely on stratigraphic sequences, mineral composition, and grain size of the matrix of the tills, indicate at least two major intervals of readvance during the general withdrawal of the Illinoian ice.

Northwestern Illinois Drift—The age of the drift mapped as Illinoian in northwestern Illinois (pl. 2) has been controversial for many years (Frye et al., 1969, fig. 3). During the time that the Woodfordian glaciers existed along the south side of the area, the Illinoian till plain was intensely dissected, and in large areas Wisconsinan rather than Sangamonian weathering profiles are developed in the top of the drift. Erosion was also intensified by the high relief of the thin Illinoian drift that mantled a mature topography. The Illinoian glacier crushed and deformed the Galena Dolomite in many hills. In places blocks large enough to be quarried have been shoved over bodies of till (Leighton and Brophy, 1961; Doyle, 1965). Although the drift is thin, many glacial features such as the Adeline-Forreston esker and the Hazelhurst kames were preserved when the ice stagnated (Flint, 1931; Frye et al., 1969).

In much of the area north of the Pecatonica River the dissection is comparable to that on the Kansan drift, and, in some exposures along the margin of the drift at the contact with the Driftless Area, pebbles of igneous rocks preserved in a matrix of residual clay on dolomite give the impression of being older than Illinoian. However, in the absence of sections showing more than one till, all the drift outside the Altonian limits is assigned to the Illinoian. Differentiation of the Illinoian drift is based largely on composition (Frye et al., 1969).

Glacial Lakes—Lake and slackwater deposits occur in prominent terrace remnants in the Mississippi and Illinois Valleys above St. Louis and are referred to Lake Brussels (Leighton and Brophy, 1961). They were earlier described by Robertson (1938) as the Cuivre terrace and by Rubey (1952) as the Brussels Formation and the Brussels terrace. Because Illinoian ice crossed the Mississippi River at St. Louis, providing a dam for the lake, the deposits have been interpreted as Illinoian. Although the distribution of the deposits strongly favors that interpretation, it has not been demonstrated that either the Sangamon Soil or the Roxana Silt overlies the lake deposits. The occurrence of pink silts in the exposures at Auer Landing (SE NE Sec. 28, T. 13 S., R. 1 W., Calhoun County), described by Rubey and by Leighton and Brophy, suggests that the deposits may have been a source for the pinkish brown loess in the Roxana Silt. Exposures are limited and the Auer Landing Section may not be typical for the terrace. Consequently, the age remains uncertain.

In western Illinois the Illinoian ice blocked eastward flowing streams and formed lakes in which thick deposits of clays, silts, and sands accumulated. Lake McKee (fig. 9) in Adams County and a lake at Pearl Prairie in Pike County are examples (Frye and Willman, 1965b).

The Ancient Mississippi Valley was blocked by the advancing Illinoian glacier near the Big Bend of the Illinois Valley, where a lake named Lake Moline (Anderson, 1968) was formed. This lake was overridden by the Illinoian glacier, and much the same area was later covered by Lake Milan when the Woodfordian ice reached the Ancient Mississippi Valley in the Big Bend area.

In many localities the rivers were diverted into new channels by the Illinoian ice, including the headwaters of the Apple River (Trowbridge and Shaw, 1916), the Mississippi River at Rock Island (Leighton and Ekblaw, *in* Trowbridge et al., 1935, p. 64; Anderson, 1968), at Warsaw (Leverett, 1921, 1942a), and at St. Louis and Fountain Bluff (Leighton and Brophy, 1961), and the Illinois River at Peoria (Horberg, Larson, and Suter, 1950).

Loess—Very little loess of Illinoian age is found on the Illinoian drift, and that little only near the margin. However, outside the area of Illinoian glaciation, the Loveland Silt, which appears to have been largely loess, is widespread. Much of the Loveland was deposited when the ice was advancing and when it reached its maximum extent. The Petersburg Silt beneath Illinoian till is in large part waterlaid, but the upper part in many exposures is loess-like. The Teneriffe Silt, which occurs on the Illinoian drift, combines with the Petersburg to form the Loveland Silt. As the Loveland extends down to the level of the Mississippi River floodplain, the surface of the Illinoian valley fill was lower than tne present floodplain, which accounts for the absence of Illinoian terraces.

Sangamonian Interglacial Age

Many of the bedrock valleys were filled with drift by the end of Illinoian glaciation, and the Sangamon Soil extends across these valleys without notable depression (Horberg, 1953). Others, such as the Ancient Mississippi Valley near Princeton were not completely filled. When the Illinoian ice melted, the Mississippi River returned to its pre-Illinoian channel from the present Mississippi Valley to the Illinois Valley.

The relatively flat till plains were essentially stable surfaces during Sangamonian time. Poorly drained soils with

local accumulations of accretion-gley (Frye et al., 1960; Frye, Willman, and Glass, 1960; Willman, Glass, and Frye, 1966) are characteristic of the flat till plain. For many years the accretion-gleys were interpreted as in-situ products of the weathering of the till and were called gumbotil (Kay, 1916; Kay and Pearce, 1920; Leighton and MacClintock, 1930, 1962; Ruhe, 1965). Sediments other than the accretion-gleys are rare. However, in the area of the Kaskaskia ridged drift, several basins that until recently held lakes contain organic-rich muds that may record climatic and biologic changes in the region since Illinoian time (Jacobs and Lineback, 1969; Jacobs, in press).

Wisconsinan Glaciation

Altonian Time

The beginning of the Wisconsinan Age in Illinois is represented by the slow accumulation of wind-blown silt on the bluffs and uplands bordering the Ancient Mississippi Valley. The mixing of this silt, which contains unweathered minerals, with clay, sand, and pebbles from the top of the Sangamon Soil, mostly by slopewash, creep, and burrowing animals, produced a widespread colluvial zone at the base of the Altonian Roxana Silt.

The Roxana Silt records many of the events of Altonian time. The lower members, separated by soils, indicate alternate glaciation and deglaciation, but the younger loesses, judged on the basis of their pinkish cast and radiocarbon dates, are related to glaciers that entered northeastern Illinois and deposited the Argyle and Capron Till Members of the Winnebago Formation (Kempton, 1963, 1966; Kempton and Hackett, 1968b; Frye et al., 1969). The vermiculitic composition of the clays suggests that the ice came from a more northerly source than the typical drift of the Lake Michigan Lobe.

The Roxana Silt is a widespread formation, almost continuously present in the area outside the Woodfordian drift and present at many places beneath the outer 30 to 40 miles of the drift. It generally composes 20 to 30 percent of the total loess thickness (pl. 3) in the area outside Woodfordian glaciation.

The distance to which the Altonian glaciers extended southward into Illinois is uncertain. Although tills at Danville and Bloomington appear to be stratigraphically equivalent to the Altonian (Ekblaw and Willman, 1955; Willman, Glass, and Frye, 1963), the correlations have been questioned (Johnson, Gross, and Moran, in press). The Altonian ice may have reached at least far enough south to have built a moraine that blocked an eastward flowing stream at Wedron, La Salle County, resulting in a lake that would account for Farmdalian sediments in the Wedron Section (table 6).

Lake silts along the Yellow Creek and Pecatonica Valleys above Freeport, Stephenson County, and along the north side of the Pecatonica Valley below Freeport, were deposited in a lake, or lakes, formed by the Pecatonica Lobe of Altonian ice that extended up the Pecatonica to Freeport (pl. 2). Hershey (1896d) named it Lake Silveria (fig. 9). The Altonian age of the upper part of the deposits is indicated by their slight weathering before deposition of the Peoria Loess.

Farmdalian Time

During Farmdalian time, the upper part of the Roxana Silt was leached of carbonates, but a weathering profile with a B-zone is recognizable only in areas of thin loess that probably were leached during deposition. The Farmdale Soil is the only buried soil in which peat and organic-rich silts are common. It appears to indicate a cooler climate than the other soils, probably cooler than the present. The peaty beds are preserved in the area where they were buried by Wisconsinan drift, but elsewhere dark-colored organic-stained silts resting on the Roxana Silt may be the residue of oxidized peat beds.

Woodfordian Time

Lobes and Sublobes—During Woodfordian time the glacier from the Labradorean center flowed westward from the Lake

Erie Basin and met the glacier moving southward from the Lake Michigan Basin (figs. 5, 12). In Illinois the contact of the lobes is represented by the convergence of moraines in a reentrant, called the Gibson City reentrant for Gibson City, Ford County. The southwestward direction of the contact and its position southwest of the center line of the Lake Michigan Lobe suggest that the Lake Erie Lobe arrived slightly in advance of, or had a somewhat greater impetus than, the Lake Michigan Lobe. However, both lobes had sufficient continuity of flow to retain a lobate form that persisted during the cyclical retreats and readvances of the ice front through the interval of withdrawal and the deposition of the Wedron Formation.

Although the orientation of the moraines relates the lobe from the east more directly to the Erie Lobe, it may be a combination of both Erie and Saginaw Lobes. The youngest drift in the lobe in Illinois, the Iroquois Drift, is largely a more silty and bouldery till than till in the other moraines, and it may represent an advance of the Saginaw Lobe (Zumberge, 1960; Wayne and Zumberge, 1965). There is little, if any, evidence of stagnation of the ice during the deposition of the Lake Erie Lobe drift.

The glacier advancing southward from the Hudson Bay region encountered the trough of the Lake Michigan Basin and formed the Lake Michigan Lobe (fig. 12). At the southern end of the basin, the ice overrode the escarpment of Silurian dolomite and spread southward to meet the Erie Lobe ice, southwestward to the Peoria region, and westward nearly as far as the present Mississippi Valley.

When the ice encountered the Ancient Mississippi Valley at the present Big Bend of the Illinois Valley, near Hennepin, Putnam County, the bedrock hills forming the west bluffs of the valley diverted part of the ice southward down the valley to form the Peoria Sublobe, and part northwestward up the valley to form the Green River Sublobe. On the north side of the lobe, the ice encountered the deep channels of the Troy and Ancient Rock Valleys (fig. 4) and spread northwestward to form the Dixon Sublobe. Both the Green River and Dixon Sublobes appear to represent only a single pulse of the ice front, following which there was a major withdrawal.

When the ice readvanced to the position of the Bloomington Morainic System (pl. 1), the westward bulge persisted, but the differentiation into the Green River and Dixon Sublobes nearly disappeared. The new configuration shown by the Bloomington through the Farm Ridge Moraines is called the Princeton Sublobe. The slight indentation in the Bloomington Moraine disappeared entirely when the Shabonna and Arlington Moraines were built.

A deep, sharp reentrant separates the moraines of the Princeton Sublobe from north trending moraines, deposited along the side of the main Lake Michigan Lobe, that are deposits of the Harvard Sublobe (fig. 12). The Harvard Sublobe moraines also show a slight westward bulge, and they meet the westward trending moraines of the Green Bay Lobe in a sharp reentrant 15 miles north of the Wisconsin state line.

The moraines younger than the Peoria, Princeton, and Harvard Sublobes are essentially parallel to the Lake Michigan shore (pl. 1), show no effect of the bulging of the earlier sublobes, and are deposits of the Joliet Sublobe (fig. 12).

Drift Composition — The drift of the Lake Michigan Lobe has a distinctive composition that shows the extensive erosion of the dark gray to black Devonian and Mississippian shales in the Lake Michigan Basin and the dolomite of the Silurian escarpment. Both characteristics diminish in the older Woodfordian drift because the ice spread farther southwestward and deeply eroded the lighter colored Pennsylvanian shales, siltstones, and sandstones. A progressive change in direction of flow from the Canadian area, probably to a more westerly source, is suggested by the progressive increase in epidote relative to garnet in successively younger Woodfordian moraines.

Lemont Drift—The Valparaiso Drift in the vicinity of Lemont overlies a highly

silty till that intertongues with, and in places is replaced by, gravel, sand, and silt (Goldthwait, 1909; Fisher, 1925) that has been called the Lemont drift (Bretz, 1939, 1955). Lemont drift is retained as an informal unit. It is well exposed along the Des Plaines Valley and the Calumet Sag Channel, where they cut through the Valparaiso Morainic System, and in the Lake Chicago Plain near Worth, Cook County. Some of the deposits may represent overridden, early Lake Chicago beach, lake, and dune sediments, which would account for the distinctive composition of the drift. The age of the Lemont drift is uncertain. Bretz questionably correlated the drift with the Illinoian, noting that the thin Valparaiso Drift mantled the slopes of valleys cut into the Lemont drift. Horberg and Potter (1955) described a leached zone on gravel in the Lemont drift, where it was overlain by Tinley Drift at Worth, as a truncated Sangamon Soil and interpreted the drift as Illinoian. Frye and Willman (1960) suggested that the drift might be Altonian in age because the weak profile of weathering could be equivalent to the Farmdale Soil. Although the preservation of such a large body of Illinoian drift through the repeated Wisconsinan glaciations is not impossible, the nearest definite remnants of Illinoian drift are about 30 miles southwest. The relations do not eliminate the possibility that the Lemont drift is Woodfordian in age. Its composition suggests correlation with the Haeger Till Member of the Wedron Formation, in which case it would be overlapped in the Lemont region by the Wadsworth Till Member. Kempton (personal communication) suggested correlation of the Lemont drift with the Malden Till Member.

Regimen of the Ice—Most of the Woodfordian sublobes left a succession of moraines, indicating a pulsing retreat and readvance during the withdrawal of the ice. Evidence of stagnation of isolated segments of the glacier occur only in local areas. No stagnation areas are recognized in the Peoria Sublobe except for a small area at the Gibson City reentrant. The drift of the Green River and Dixon Sublobes is thin and so eroded or covered by outwash and sand dunes that the behavior of the ice is conjectural. The marginal morainic patches are small and named separately.

In the Princeton Sublobe, stagnation features are characteristic of the Bloomington Morainic System where it crosses the Ancient Mississippi Valley and along its back slope in the northern area near the Harvard Sublobe. The contact of the Princeton and Harvard Sublobes is a complex of stagnation features, and the Gilberts Moraine of the Harvard Sublobe is characterized by such features. In the Joliet Sublobe, the Lake Border Moraines have good continuity and slight evidence of stagnation, but preservation of kames, eskers, and kettles in thin drift, along with the weak moraines, suggest that the Valparaiso ice became stagnant in some areas.

The contrast between the flat Illinoian till plain and the ridged surface of the Woodfordian plain is more than an indication of differences in age. It reflects notable differences in climate. Whereas the Illinoian ice had the momentum to advance much farther south into the temperate zone, it retreated with weak readvances, minor moraine building, and general dissipation by stagnation. The Woodfordian ice, on the other hand, continued to flow, with only local areas of stagnation, during the entire interval of withdrawal and moraine building. The minor climatic cycles that produced the Woodfordian moraines appear to be characterized by a relatively gradual change from cool to warm during the building of the moraines and a much more rapid change from warm to cool at the beginning of a readvance.

The pulsation of the Woodfordian ice front can be explained only by an extraordinarily high rate of ice flow and ice-front fluctuation, which in turn indicates climatic cycles with extremes great enough to cause rapid reversals in movements of the ice front. The pattern of the Woodfordian moraines in Illinois indicates a minimum of 32 episodes of moraine building in the interval from 14,000 to 20,000

radiocarbon years before the present, which gives a maximum of 190 years per cycle. Several more moraines, eliminated because they could be equivalent to others, and several minor moraines, could be added. Four of the readvances may have exceeded 50 miles, and an average of 5 miles for the others is probably conservative. The ice front, therefore, fluctuated a total distance of about 900 miles in a net retreat of 200 miles. If half the available years is expended in building the moraines (only about 100 years per moraine) and in reversing direction before readvance, 3,000 years remains for the ice front movements. This gives a rate of ice front movement of about 0.3 mile, or 1,584 feet, per year. As the ice also was melting, it must have been advancing at a greater rate, at least during the readvances. This seems to be almost a minimum estimate, but it is several times greater than conventional estimates in other regions (Horberg, 1956; Goldthwait et al., 1965). Bouldery gravel outwash, torrential bars, flooded and scoured uplands, and deeply entrenched valleys indicate intervals of rapid melting and great volumes of meltwater during Woodfordian glaciation.

Some of the moraines may not represent separate pulses of the ice front. Along the sides of the lobes, the fluctuations of the ice front were in a narrow zone, resulting in the truncation of earlier moraines and deposition of overlapping till sheets. A few closely spaced, essentially parallel moraines, such as those in the morainic systems, may be true recessional moraines resulting from a stand of the ice front without readvance. The stratigraphic sequences of till sheets suggest, however, that this is not commonly the case, and it seems likely that the climatic cycles normally would favor readvances. A few morainic ridges are overridden moraines with the earlier morainic topography showing through the younger drift. A few may be features of much older drift, such as buried hills of the Illinoian ridged drift. Others may be buried erosional features. Obvious features of these types are not mapped as moraines of the surface drift. Nevertheless, the origin of some of the ridges mapped as moraines is questionable and requires further study.

The validity of the pattern of moraines as a record of the pulsing retreat of the ice is frequently questioned, because of the exceptions listed above and others. However, the long-established interpretation of the moraines in Illinois as ice marginal features is supported by the following:

a) The ground plans and shapes of the moraines conform to reasonable margins for the lobes.

b) The moraines are largely continuous surficial features rarely showing any relation to bedrock topography.

c) Some moraines have a distinctive composition that shows they are depositional features on a relatively flat till plain.

d) The moraines have comparable quantities of drift. Many average about 2 miles wide and have crests about 50 feet high. Some of the morainic systems with three crests are approximately equivalent to the superposition of three moraines.

e) Variations in quantity of drift between the front and sides of the lobes, notable in some moraines, is particularly suggestive because it is best explained by variations in position of the ice front and the rate of flow of the ice.

f) The gradation from the relatively rough topography of the moraines to the smooth surface of the groundmoraines is related to the increasing rate of ice-front retreat.

g) Sequences of several tills separated by waterlaid deposits show the repeated advances and retreats of the ice front.

Loess—The Woodfordian was a time of great loess accumulation. More than 90 percent of the loess on Woodfordian drift (pl. 3) is Woodfordian in age (Frye, Glass, and Willman, 1968). Outside the Woodfordian drift, 65 to 75 percent of the loess is Woodfordian. Loess deposition was favored by the climatic extremes that produced the large quantities of out-

wash, the alluviation of the valleys, and the strong winds that came dominantly from the northwest during the intervals of decreased rainfall and melting in the winter season. The loess began to accumulate as soon as the glaciers reached the headwaters of the Mississippi, Illinois, Wabash, and Ohio Rivers, and deposition was continuous except for minor interruptions in the later stages. The loess averages about 5 feet thick over 90 percent of Illinois. Such a volume of loess is equivalent to a fill of 75 to 100 feet in the source areas, the bottomlands of the major rivers. The loess thicknesses shown in plate 3 are based on maximum thicknesses underlying relatively undissected uplands. Beyond the limit of Woodfordian glaciation, the loess thickness includes deposits of both Altonian and Woodfordian age.

The advancing Woodfordian glaciers overrode, and in places eroded, the unweathered loess and, as the ice melted, the loess was deposited on unweathered till. These relations permit the three-fold differentiation of the loess — Peoria for the undifferentiated loess outside the Woodfordian drift, Morton for the loess below the Woodfordian drift, and Richland for the loess above it. The Woodfordian loesses are similar in appearance wherever they occur and are differentiated only by stratigraphic relations. Changes in source areas of the outwash from which the loess was blown resulted in changes in mineral composition that record significant events in the history of the valleys (Glass, Frye, and Willman, 1968).

During the early stage of loess deposition, outwash from the Upper Mississippi Valley continued to flow through the Ancient Mississippi Valley, and the loess from that source is characterized by a high montmorillonite content. When the Lake Michigan Lobe of the Woodfordian glacier reached the Ancient Mississippi Valley at the Big Bend near Hennepin and diverted the Mississippi River to its present channel below Muscatine, Iowa, the major source of montmorillonite to the Illinois Valley was cut off, and the high illite outwash from the Lake Michigan Lobe was the source of the loess. The change in composition occurs within the Morton Loess and the lower part of the Peoria Loess and dates the time of diversion of the Mississippi River at about 21,000 radiocarbon years B.P. (Glass, Frye, and Willman, 1964).

The contrast in composition between the pink till of the Tiskilwa Till Member of the Wedron Formation and the yellow-tan till of the succeeding Malden Till Member occurs along the Illinois Valley in the Richland Loess and the upper part of the Peoria Loess (Frye, Glass, and Willman, 1968). The loess does not change in color, but the clay mineral composition changes abruptly from an intermediate to a high illite content.

Along the Illinois Valley in the Big Bend area, a zone characterized by high content of montmorillonite at the top of the Richland Loess results from blow-over of loess from the Green River Lowland following the major episode of Woodfordian outwash along the Illinois Valley (Glass, Frye, and Willman, 1968). The strong winds from the northwest may have formed the elongated ridges called "pahas" (McGee, 1891; Leverett, 1942b) in Rock Island and Whiteside Counties. On the lee side of the Bloomington Morainic System in Bureau County (MacClintock and Willman, 1959), the thickened loess and the sand dunes derived from the Green River Lowland may also have been produced by these winds.

The pahas in the area between the Mississippi and Rock River Valleys, extending from Port Byron, Rock Island County, north to Fulton, Whiteside County, are uniformly oriented northwest-southeast and are composed largely of loess and windblown sand; some of them are more than 50 feet high. This area is the eastern end of a broad area of pahas extending across Iowa to the front of the Des Moines Lobe. The pahas have been the subject of much speculation and only slight investigation. They have generally been interpreted as features of wind deposition, and some probably are, but, at the sharp south margin of the paha area in Illinois, the crests

of the pahas are about level with the smooth loess-mantled upland to the south, and the ridges appear to be erosional features carved from the loess by wind. Hobbs (1950) cited evidence of wind erosion in Iowa, relating it to strong winds blowing off the Des Moines Lobe, but Ruhe et al. (1968) attributed the distinctive topography of the region to stream erosion.

Glacial Lakes—When the Woodfordian ice blocked the Ancient Mississippi Valley at the Big Bend in the Illinois Valley at Hennepin, Lake Milan (Shaffer, 1954a) formed in the valley above the dam, spilled over a col near Andalusia, and gave the Mississippi River an outlet to the west, to the Ancient Iowa Valley near Muscatine (fig. 9). At its maximum extent the ice again blocked the river near Hillsdale, Rock Island County, and formed Lake Cordova (Shaffer, 1954a), which spilled over the divide near Port Byron and completed the diversion of the Mississippi River into its present channel. Shaffer (1954a) extended the ice into Iowa, which formed a third lake, Lake Savanna, in the valley above Fulton. However, the extension of the ice into Iowa seems improbable and the deposits of Lake Savanna are assigned to Lake Cordova.

Many lakes were formed in the low areas behind the moraines and in front of the glacier. Where the deposits in these lakes are preserved between tills they are strong evidence of the readvances. Lake Douglas (Ekblaw, 1959; Gardiner, Odell, and Hallbick, 1966), Lakes Ancona and Lisbon (Willman and Payne, 1942), and the early stages of Lake Chicago (Bretz, 1955) are examples of such lakes (fig. 9). Many others are present, most of them not named.

In the Illinois Valley, ice-front deltas were deposited at a uniform elevation of 600 feet in a lake called Lake Illinois that existed through the building of several moraines (Leighton, *in* Fisher, 1925; Willman and Payne, 1942) (fig. 9). The deltas occur on and between the moraines and some were overridden during readvances. Lake Illinois has been attributed to a boulder-studded dam of the Bloomington Moraine where it crosses the Illinois Valley at Peoria, and the lake persisted through the building of the Marseilles Morainic System. The dam was eroded by the Fox River Torrent, a flood indicated by coarse outwash gravels of Marseilles age in the Fox Valley in the Elgin to Crystal Lake region, Kane and McHenry Counties (Willman and Payne, 1942). Deltas occur on the back slope of the Marseilles but not on younger moraines. However, the relatively thick Richland Loess on the Illinois Valley bluffs and adjacent uplands between Peoria and the Big Bend at Hennepin must have been derived from outwash in the Illinois Valley; consequently, a lake could not have been continuously present in the valley. Although about 20 deltas have been found along the valley east of Hennepin, no deltas have been found between Hennepin and Peoria. It is more likely, therefore, that Lake Illinois was not formed until the major readvance that deposited the Dover or Mt. Palatine Moraines.

Although natural lakes resulting from ice-block depressions and uneven drift deposition are rare on Woodfordian drift in most of Illinois, in the northern 25 miles of Illinois (Lake and McHenry Counties) they are common on Bloomington through Marseilles Drifts and abundant on Valparaiso Drift. Peat and lacustrine sediments in many other basins indicate a much greater abundance of lakes immediately after the melting of the ice. The differences in abundance of lakes on the same moraines is related to differences in melting behavior, the greater surface relief resulting from the isolation of more and larger ice blocks during final melting of the glaciers in the northern area. The cooler climate of northern Illinois has favored persistence of the lakes in that region.

Kankakee Flood—During the building of the Valparaiso Morainic System, drainage from the east side of the Lake Michigan Lobe, the Saginaw Lobe, and the north

side of the Erie Lobe was discharged into the Kankakee Valley, causing the Kankakee Flood, called Lake Kankakee by Bradley (1870), Chamberlin (1883b), and Leverett (1899a) and later the Kankakee Torrent by Ekblaw and Athy (1925), Athy (1928), and Willman and Payne (1942). The existing valleys and the outlets through the moraines were inadequate to accommodate such a flood, and at the peak of flow the water spread widely over the uplands, forming Lakes Watseka, Wauponsee, Pontiac, and Ottawa (fig. 9). At their highest level these lakes spilled through gaps in the moraines to the headwaters of the Vermilion River, a tributary of the Illinois River, and to the Fox Valley through channels in the Marseilles Morainic System. As the major outlet was along the Illinois Valley, it was cut down rapidly, and the lakes were lowered and other outlets abandoned. When the flood became more concentrated and less lakelike, it scoured broad areas of the bedrock in the Kankakee Valley, and bars of angular, bouldery rubble show the erosive force of the currents. The outlet channel along the Illinois Valley was entrenched in bedrock to the Big Bend at Hennepin, but below Hennepin it greatly widened the valley in the relatively soft glacial deposits that filled the Ancient Mississippi Valley. The broad terraces along the Illinois Valley from Hennepin to Beardstown are largely erosional surfaces of the Kankakee Flood.

Thin beds of waterlaid deposits in the Peoria Loess at Alton show a temporary high level of the Mississippi River, about 50 feet above the present floodplain, and may be attributed to the Kankakee Flood. Similar beds in the Peoria Loess at Cape Girardeau, Missouri, also about 50 feet above the floodplain, are of particular interest because the Mississippi River at that level could have overflowed a col in the bedrock ridge near Thebes, Alexander County, giving the river its present straight-ahead short-cut into the Ancient Ohio Valley at the head of the Mississippi Embayment. Other cols in the ridge are only 20 feet higher. A high river level in late Woodfordian time is the most likely explanation for the Thebes Gorge, and, if it was caused by the Kankakee Flood, the gorge is about 14,000 to 15,000 radiocarbon years old.

As glacial outwash is found only in the lowest Wisconsinan terrace along the Ohio River from Hamletsburg, Pope County, to Cairo, Alexander County, it appears that the Ohio River remained in Cache Valley until late in Woodfordian time. It is not unlikely, therefore, that a high water level in the lower Ohio permitted the river to take a straight-ahead course over a low divide between the Cumberland and Tennessee Rivers, abandoning the Cache Valley in favor of the Tennessee. This could have been the same high water level caused by the Kankakee Flood in the Mississippi Valley.

Sand Dunes — When the Kankakee Flood subsided, the rivers became entrenched and large areas of sand were exposed to wind action. Along the Illinois and Kankakee Valleys, dunes, mapped as the Parkland Formation (fig. 11), were formed on the terraces formerly covered by the Kankakee Flood. In many areas the dunes migrated up the bluffs and onto the uplands east of the valleys. A thin cover of loess on some of the dunes shows that they reached the upland late in the interval of loess deposition. Other dunes low in the loess sequence indicate that dunes had formed on the terraces before the Kankakee Flood destroyed them and initiated another cycle of dune formation. The dominance of westerly winds is shown by the absence of sand dunes on the western bluffs. Of the two large terrace areas along the west side of the Illinois Valley, the terrace at Henry, Marshall County, has no dunes, and the terrace at Chillicothe, Peoria County, has relatively few prominently developed. The other large area of dunes is in the Green River Lowland (Henry, Whiteside, and Bureau Counties). Some of these dunes formed on early Woodfordian outwash and have a relatively thick cover of loess; others formed on or derived from the lowest outwash surface, which is late Woodfordian, and have only a thin loess cover. Except for local "blowouts," which exist even today, the

dunes were formed soon after the sand was exposed to wind action, and most of them have long been stabilized in their present positions.

Slackwater Lakes—The extensive lakes in the tributaries of the Mississippi, Ohio, and Wabash Rivers in southern Illinois (fig. 9) are slackwater lakes resulting largely from the great fill of Wisconsinan outwash in the Mississippi Valley and, to a lesser extent, in the Ohio and Wabash Valleys. This fill aggraded the valley floors more than 50 feet, perhaps as much as 100 feet, above its pre-Wisconsinan level. The outwash was the source of the Roxana Silt and the Peoria Loess. Deposits in the lakes are largely of silt, most of it reworked from the loess. The silt drowned the valleys so that the margins are depositional overlaps. The lake beds blend into the loess and differentiation is difficult. There are few shoreline features. The contact of the silt with modern alluvium, which also consists of silt, is likewise difficult to recognize. Except near the major valleys, the present streams are only slightly entrenched in the lake deposits, and at flood stage they spread over them, leaving indefinite boundaries in the sequence of silts.

Lake Chicago—The Lake Chicago plain, on which much of the city of Chicago is located, is a conspicuous feature because of the flatness of the lake bed and the erosional cliffs and beaches that separate it from the surrounding morainic topography. The lake plain has three prominent beaches — the Glenwood at 640 feet, the Calumet at 620 feet, and the Toleston at 600 feet. A narrow channel through the lake plain at 590 feet, only 10 feet above Lake Michigan, marks the lowest level of discharge through the outlet. Each of the shorelines was occupied more than once. Erosion of the Chicago and other outlets, readvances of the ice, and crustal warping from glacial loading resulted in shifting outlets. The lowest beaches are related to Lake Algonquin, which followed Lake Chicago when the ice freed the Straits of Mackinac and lakes in the Michigan, Huron, and Superior Basins were joined.

The Nipissing Great Lakes, which followed Lake Algonquin, discharged through the lowest channel in the outlet until erosion cut down the outlet of Lake Huron at Port Huron and established the present drainage through Lakes Erie and Ontario to the St. Lawrence River. During the transition to the present elevation of Lake Michigan at 580 feet, the last discharge through the Chicago Outlet was the Algoma lake stage, only 2,000 to 3,000 radiocarbon years ago, when the lake had a level about 15 feet higher than the present Lake Michigan (Hough, 1958). The history of the lakes is complicated, in part controversial, and is described in numerous reports (Bretz, 1939, 1951, 1955, 1959, 1964, 1966; Hough, 1953a, b, 1958, 1962, 1963, 1966; Wayne and Zumberge, 1965; and others).

Beaches, bars, and spits, associated with the Lake Chicago shorelines, consist largely of sand. Most of the lacustrine silts and clays have been washed from the lake plain above the Toleston beach, but sediments 5 to 10 feet thick commonly cover the eroded surface of the till on the surface below that beach. The features of the Lake Chicago plain have been mapped by Alden (1902) and, in more detail with much improved base maps, by Bretz (1953).

The Chicago Outlet River cut through the glacial deposits of the Valparaiso Moraine and entrenched itself in Silurian dolomite. In places, the intricately carved bedrock surface is covered only by scattered boulders. Well rounded cobbles of the dolomite form most of the coarse gravel that extends from the outlet down the Illinois Valley as far as Ottawa (Willman and Payne, 1942; Frye and Willman, 1965b). Although much finer grained, the Chicago Outlet River gravel continues in a low terrace south to Beardstown (Wanless, 1957).

Twocreekan and Valderan Time

Following the withdrawal of the Woodfordian glacier from the Lake Michigan

Basin, Lake Chicago was at a low level and the Two Creeks peat was deposited in east-central Wisconsin. This and succeeding events in the Lake Michigan Basin, during which the Valders glacier reached to the Milwaukee region, are recognized in Illinois only in the fluctuating lake stages and in terraces along the major valleys. Loess deposition probably continued, although greatly reduced, as long as the glaciers discharged outwash into the headwaters of the Mississippi Valley, but no evidence of an interruption in loess deposition at the Twocreekan interval has been found. The amount of loess of Valderan age in the Peoria and Richland Loesses is probably small.

Wisconsinan and Holocene Time

The withdrawal of the ice after the building of the Cochrane Moraine in Ontario, about 7,000 radiocarbon years ago, is accepted as the beginning of the Holocene, an old but seldom-used term that replaces "Recent" of previous Illinois State Geological Survey publications. In Illinois the Wisconsinan-Holocene boundary falls within most of the formations deposited since the glaciers withdrew from Illinois, many of which are still accumulating. It also falls within the Modern Soil where the soil is developed on glacial deposits, and it is generally missing where erosion is active. The most extensive deposits that are exclusively Holocene result from the activities of man.

Before the beginning of the Holocene, the ice had withdrawn from the headwaters of the drainage systems affecting Illinois. The regimen of the major rivers was greatly influenced by the change in sediment and a probable decline in volume, although the Illinois and Mississippi Rivers were still receiving clear-water discharge from the Great Lakes and Lake Agassiz. The major rivers changed from aggrading to eroding, entrenched themselves 50 to 75 feet into the fill of glacial outwash, and established the present meandering patterns and slowly aggrading floodplains (Rubey, 1952). An upright tree at a depth of 50 feet in the Cahokia Alluvium near Wood River, Madison County, was found to be 6,600 radiocarbon years old (table 1). Many of the smaller valleys also have established alluvial flats that are underlain by Wisconsinan-to-Holocene sediments (fig. 10).

Similar relations exist in the post-glacial deposits in the morainic areas. Lake, peat, dune, beach, alluvial, colluvial, and gravity deposits began to accumulate as soon as the ice melted. On the oldest Woodfordian drift such deposits began nearly 19,000 radiocarbon years ago. On the Valparaiso Drift they cannot be more than about 14,000 radiocarbon years old. The misleading designation of such deposits as Recent is corrected by classifying the different types of sediments as separate rock-stratigraphic units and assigning them to a Wisconsinan-Holocene age.

PRINCIPLES OF STRATIGRAPHIC CLASSIFICATION

Stratigraphic classification is the systematic arrangement of the rocks of the earth's crust by units that are, in general, tabular and tend to parallel the stratification of the rocks. The basic modern principles governing classification, nomenclature, and procedures in stratigraphic practice have been documented (Willman, Swann, and Frye, 1958; A.C.S.N., 1961). Nevertheless, in order to clarify the relation of former classification schemes to the concepts used at present, and to explain certain deviations from the published codes in the present practice of the Illinois State Geological Survey, the historical development of stratigraphic classification is reviewed briefly and the usage in this report defined.

Scientific stratigraphy came into existence more than 150 years ago. It was based originally on two concepts— younger strata always overlie older strata, and fossils can be used to identify and correlate individual sedimentary beds. Perhaps be-

cause of these two basic precepts, stratigraphy for the next 100 years was concerned primarily with the establishment of relative ages of the many rock layers and their regional correlations. In this context a scheme of stratigraphic classification developed that was ostensibly two-fold—"rock" and "time." The two were parallel and in practice were used as a single classification. This scheme was given legalistic validity by the International Geological Congress meeting in Paris in 1901, which recognized a hierarchy of time terms consisting of era, period, epoch, subepoch, age, and phase. The parallel rock classification was a hierarchy of system, series, stage, and zone. In 1933, a special committee of state geologists, working with representatives of the U.S. Geological Survey, the Geological Society of America, and the American Association of Petroleum Geologists, prepared the first widely accepted stratigraphic code in the United States, "Classification and Nomenclature of Rock Units" (Ashley and others, 1933).

It was unfortunate, in modern perspective, that the stratigraphic code of 1933 excluded Pleistocene deposits from standard usage and specified (p. 446): ". . . the time covered by a Pleistocene subdivision of formational rank is called a *stage*, and the time covered by a Pleistocene subdivision of member rank is called a *substage*." This, in practice, eliminated the use of formations, members, and other rock units in the Pleistocene. It produced a dichotomy at the base of the Pleistocene that has served to confuse Pleistocene classification ever since. Clearly, the basic tenets of classification cannot be changed for every system without defeating a major objective of classification.

One additional factor of Pleistocene classification that contributed further to confusion and misunderstanding was the nomenclature and classification of glacial moraines and alluvial terraces. Moraines were named and described as though they were time units and used as though they were rock units, but they possessed the properties of neither. Nor did they fit properly into any existing scheme of classification.

More than 20 years ago several organizations started to restudy the problems of stratigraphic classification and nomenclature. Most significant of these was the American Commission on Stratigraphic Nomenclature composed of representatives of federal and state government geological surveys, the official geological organizations of Canada and Mexico, and leading national societies. The A.C.S.N. produced a series of Reports, Notes, and Discussions addressed to the problems of stratigraphic classification. Other groups at state, national, and international levels also have been working on the problem.

In 1958 the Illinois State Geological Survey issued a report on its official classification policy (Willman, Swann, and Frye, 1958), and in 1961 the A.C.S.N. issued its proposed stratigraphic code for North America (A.C.S.N., 1961). The principles of classification briefly reviewed here, and followed in this report, are modified only in details from these two publications.

The present philosophy of Pleistocene classification differs from the former philosophy in two fundamental aspects. First, it contends that multiple hierarchies, or schemes of classification, based on different sets of characteristics and criteria can and should exist side by side, entirely independent of one another. Second, it holds that deposits of the Pleistocene must be classified under the same set of rules as deposits in the older and larger segment of the rock column. Only rock- and time-stratigraphic classifications are required; all rocks belong to some formation and some system. Additional classifications may be developed for special needs.

The effectiveness of multiple classification depends on recognition of two factors—(1) the different classifications are entirely independent; (2) the particular classification used can always be identified from the name of the unit. Consequently, the classifications can be intermixed as needed in descriptions (table 6) and for map units without confusion. The use of multiple classification for mapping is ex-

emplified by the Chicago region map by Willman and Lineback (1970).

A review of the classifications used in various areas of the country in "The Quaternary of the United States" (Wright and Frey, 1965) shows that the multiple classification scheme has not received favor from Pleistocene geologists. In most of the papers it is difficult to determine what type of classification is being used. The most common form resembles time-stratigraphy, but with slight recognition of the need for reference to a type section. In most papers there is a mixture of time and genetic terms. Although this may be adequate for use in individual papers, it does not provide a workable basis for regional communication. Greater uniformity in practice clearly is needed and will become even more necessary as studies of Pleistocene sediments are intensified. The multiple classification scheme has the advantage of flexibility, and it can be modified to meet the changing needs.

For Illinois the Illinois Geological Survey recognizes the following independent categories of stratigraphic classification:

Time-stratigraphic
Rock-stratigraphic
Biostratigraphic
Soil-stratigraphic
Morphostratigraphic
Sequences
Cyclical
Facies (informal)
Hydrostratigraphic (informal)
Other types of informal units
  such as "pay-zones"

In the discussion and classification of Illinois Pleistocene deposits presented here, only four of these classifications are formally used (fig. 1)—rock-stratigraphic, soil-stratigraphic, morphostratigraphic, and time-stratigraphic. Examples of these four classifications are given below.

Time-stratigraphic (derived units of geologic time in parentheses)
  Quaternary System (Period)
    Pleistocene Series (Epoch)
      Wisconsinan Stage (Age)
        Woodfordian Substage

Rock-stratigraphic
  Wedron Formation
    Tiskilwa Till Member

Soil-stratigraphic
  Sangamon Soil

Morphostratigraphic
  Illiana Drift

Each of these four classifications, as used for Illinois Pleistocene deposits, are briefly described. A fifth category, biostratigraphic, is in principle applicable to these deposits, but formal biostratigraphic units have not been named in the Illinois Pleistocene. The classification of geologic time, which might be considered as still another category, is not a scheme of stratigraphic classification. Rather, it is a means of subdividing time and is wholly derived from the evidence of the rock column. It is based on the time-stratigraphic classification and for that reason cannot be considered to have independent existence. Radiometric time determinations do have independent existence, but do not compose a classification.

Two other classifications that are not used for the Illinois Pleistocene are facies classification and geologic-climate classification. Facies classifications are numerous, but those of greatest concern in stratigraphic nomenclature involve rock facies of different lithologies but of the same approximate age and genetically related. The most prominent and widespread facies are accepted as rock-stratigraphic units. The interpretation of rock-stratigraphic units used in Illinois emphasizes continuity of strata through gradational change rather than narrowly conceived lithic units. Within many of the Pleistocene formations, facies are almost too numerous to mention. The term "facies" or "facies relation" is used to refer to intertonguing or lateral gradations of different rock types within rock-stratigraphic units. Although facies intertongue, contemporaneous rock-stratigraphic units do not. Where intertonguing exists, arbitrary vertical boundaries are drawn between rock-stratigraphic units to prevent repetition of a unit in the same sequence. In developing a rock-stratigraphic classifi-

cation of the Pleistocene in Indiana, Wayne (1963) differentiated many units on the basis of facies relations, and most of his units are not equivalent to units recognized in Illinois.

Geologic-climate units, described for use in the Quaternary by the A.C.S.N. code of 1961 (p. 660), are defined as "an inferred widespread climatic episode defined from a subdivision of Quaternary rocks." It was pointed out that the boundaries of such units in different latitudes may be of different ages, and that the units might be extended without regard to changes of facies of the rocks, soils, or other materials of the unit. They clearly are neither time-stratigraphic nor rock-stratigraphic, but are intended to record and classify climatic pulses. At present it appears that the climatic record in Illinois is much too complex, and for many sediments too difficult to evaluate, to serve as a useful basis for classification of the Pleistocene deposits.

Rock Stratigraphy

Rock-stratigraphic units are defined and recognized on the basis of observable lithology without necessary regard to biological, time, or other types of criteria. They must be sufficiently distinctive to be recognizable by common field and subsurface methods. Rock-stratigraphic units are the ones most used by the applied geologist, and for that reason practicality should be kept in mind when they are defined. Their boundaries are preferably placed at sharp contacts of lithologic change, but they also may be drawn arbitrarily in transitional zones. To be properly defined, a rock-stratigraphic unit must be described from a specific type locality, preferably where the upper and lower contacts and bounding units can be described. Once described, a rock-stratigraphic unit may be traced laterally, even though its lithologic character changes gradationally, so long as the integrity of the unit as a continuous body of rock can be recognized. On the other hand, where a recognizable boundary disappears (e.g., at the limit of an overlying till sheet) and the unit becomes inseparable from a subjacent or superjacent unit that has been separately defined, the stratigraphic name should not be continued. This principle is well illustrated by the relations of the Morton, Peoria, and Richland Loesses (fig. 8). For the sake of practical utility, as previously noted, rock-stratigraphic units do not intertongue, and the same term does not appear twice in the rock succession. To avoid such an occurrence, a unit must be arbitrarily terminated by a vertical cut-off and appropriate new units defined.

The accepted hierarchy of rock-stratigraphic units is as follows:

Megagroup
  Group
    Subgroup
      Formation
        Member
          Bed

The formation is the fundamental unit. That is, all rocks belong to some formation, and a complete sequence of other units is not required. Only formations and members are used in the classification of the Pleistocene of Illinois presented here.

Acceptance of the formation as the fundamental unit of rock-stratigraphic classification provides a uniform starting point in the ranking of units and a means of attaining uniformity in practice. In Pleistocene glacial deposits, as well as in Paleozoic rocks, the variability of the sediments is such that several types or sizes of units, based on major and minor differences in lithology, can be differentiated. Consequently, there are several alternatives for formational units and a choice must be made. Units that are of the same general scope that can be used to develop a complete sequence of formations must be chosen. This obviously is not easy in the Pleistocene, nor a choice that can be followed entirely consistently.

One alternative would be to recognize the entire sequence of glacial and glacial-derived sediments as a formation and the more traceable subdivisions as members, a complete sequence of which is not required. A possible modification would be

to differentiate the loess and the glacial deposits as two formations. The effect of such large formational units, however, is to leave rock-stratigraphy in essentially its present state of limited usefulness. It is our purpose here to show that smaller units can be adopted as formations.

At the other extreme, many of the named members of the formational units recognized here are distinct lithologic units that could conceivably be called formations. At present, however, most of these units do not have the regional continuity desirable for formational units, and, a more important point, in much of the column similar types of units cannot be differentiated to establish a complete formational sequence. This practice would produce a much larger number of formations than seem to be needed.

The formations recognized here can be differentiated by origin into five general types—the loesses, the outwash, the glacial lake sediments, the dominantly till units, and the surficial sediments that, at least in part, are still in process of accumulation. Although these are genetic groupings, their different origins impart distinctive compositions, grain size, and structure, and the formations are differentiated on lithology and not on origin. Nearly all of the formations are widely distributed mappable units.

The widespread loesses and related silt deposits that mantle most of the state are readily distinguished in the field by color, texture, and soils. They are widely traceable, and, locally at least, they are as thick as many bedrock formations. Most of such units are not traceable where they interfinger with the till units, in which case they are included in the till formations. However, two silts, the Morton Loess at the base of the Woodfordian drift and the Petersburg Silt at the base of the Illinoian drift, are distinctive, widespread units and are classified as formations. Because they are continuously superimposed on other formations, the loess formations are not usually mapped separately. In practice, the entire loess sequence frequently is omitted on surficial maps because it masks a wide variety of units that are desirable to map. For most uses a separate thickness map for the loess is preferred.

The outwash deposits are the dominantly sand and gravel deposits of glacial streams in outwash plains, valley trains, and ice-contact situations. These formations also include similar deposits made by outlet rivers of glacial lakes and bars on the floors of glacial sluiceways. Like the loesses, the outwash deposits locally interfinger with the dominantly till units, and they are differentiated only where they are the surface deposits or directly underlie loess.

The glacial lake sediments are dominantly silt and clay, but they include, and have a facies relation with, beach, bar, and spit deposits consisting largely of sand and, locally, minor amounts of gravel. Most of the lakes were ice-contact lakes, but some were formed when outlets through moraines were inadequate to accommodate glacial floods, and others were slackwater lakes formed when aggrading valley trains in major valleys blocked tributary valleys. The lake deposits cover large areas of Illinois and, like the outwash deposits, are recognized as formations only where they are the surface deposits or directly underlie the loess.

The dominantly till formations contain nearly as much gravel, sand, and silt in some areas as they do till; very locally till is in the minority. Although the two Wisconsinan till formations are less compact and less oxidized than the tills of Illinoian and older age, the five till formations are differentiated largely on stratigraphic relations and on the soils that separate them and serve as effective key beds. These formations do not extend beyond the limit of glaciation.

A type of rock-stratigraphic unit that is in accordance with the stratigraphic codes but has generally not been defined is the unit that has an upper boundary at the modern surface and is, at least in some places, in the process of formation (fig. 1). Many of these surficial deposits are mappable units and, from a standpoint of practical utility in problems of environmental

geology, are of paramount importance. Yet, largely because they are at least in part Holocene in age and are bounded at the top by the top of the Modern Soil, they have not in the past been formally recognized as formations and members. In the classification presented here, such units as the Cahokia Alluvium, the Grayslake Peat, and the Parkland Sand are formally recognized. If rock stratigraphy is to meet the needs of modern application, these highly relevant units must be formally recognized.

Informal units that in some respects resemble rock-stratigraphic units have been recognized locally. Most significant of these are mineral zones in the loesses. Laboratory analyses of clay minerals from such zones have been used to identify zones that are not recognizable in the field as rock-stratigraphic units. Laboratory determinations of such characteristics as clay minerals, heavy minerals, and grain size provide valuable supplemental data for the correlation of rock-stratigraphic units, but units based solely on laboratory data do not qualify as formations or members.

Informal rock-stratigraphic units of increasing importance are the man-made deposits. Such materials are not formally defined as formations and members because they are not "naturally occurring." However, many of them are mappable, extensive, and as thick or thicker than many of the formally defined units. These man-made deposits may be classed in four general categories: (1) made-land, (2) deposits in artificial lakes, (3) overturned earth material in strip mines and excavations, and (4) artificial fills such as sanitary land fills, mineral waste piles, and fills for highways and railroads. As man and his products become an ever increasing part of nature, it seems that only time is necessary before his deposits are accorded formal status in rock stratigraphy.

Soil Stratigraphy

A soil, as defined in stratigraphy, is a weathered zone formed in a surface or near-surface environment. Zonal soils differ from rock-stratigraphic units in that, for the most part, they are derived by the alteration of rocks in situ rather than by deposition of transported material. Used thus, the name "soil" applies to the entire profile of weathering. Its base is gradational and is at the top of the unaltered parent material. In contrast, its top is a sharply defined line at the top of the A-zone of the profile, or the truncated surface at some point lower in the profile. A soil-stratigraphic unit is quite independent of the rocks in which the profile is developed, and it is defined on the basis of the stratigraphic position of the top of the soil. For example, the Sangamon Soil may be developed in deposits of late Illinoian age (e.g., Tindall School Section, table 6) or in deposits as old as the Pennsylvanian or older (e.g., Lone Oak Section, table 7). To be classed as Sangamon, the top of the profile must at some locality be overlain by deposits of the Roxana Silt, Winnebago, Henry, or Equality Formations. The deposit in which the soil profile is developed is assigned to its appropriate rock-stratigraphic unit.

Many of the major soil-stratigraphic units (fig. 1) are named from the same localities as time-stratigraphic units, and this has led to the assumption by some workers that the soil units were merely time-stratigraphic units in different form. Such is clearly not the case. Although the duplicated terms (Afton, Aftonian; Yarmouth, Yarmouthian; Sangamon, Sangamonian; Farmdale, Farmdalian) are retained because of long established use, all of the newly described soil-stratigraphic units introduced here (Pike, Chapin, Pleasant Grove, Jules) are named independently of time-stratigraphic units.

In essence, the stratigraphic utility of a soil is to define an unconformable surface that can be identified and widely traced. The morphologic characteristics of the profile also can be used to estimate the time interval represented by the unconformity and as an index to the climate and vegetational cover of the surface during this time, but these factors are ancillary to stratigraphic classification. Also of secondary

concern is the classification of the profile into the groupings recognized in soil science. For example, within the Sangamon Soil of the Midwest and Southwest are examples of Planasols, Podzolic soils, Prairie soils, Chernozems, Chestnut soils, Brown soils, and even Red Desert soils, but as long as the stratigraphic position of the unconformable surface at the top of the profile meets the requirements of the definition, these are stratigraphically all Sangamon Soil.

In Illinois, soil stratigraphic units are also extended to include the deposits of accreted intrazonal soils, the tops of which occupy the same stratigraphic position. As this practice is long established (e.g., Leverett, 1899a) we have continued it. In such cases the deposit is separately classified as a rock-stratigraphic unit (e.g., Berry Clay Member of the Glasford Formation) quite independently of its inclusion in a soil-stratigraphic unit (fig. 7). Such accreted soils may be largely clays (like the widespread accretion-gleys), peats, or organic-rich silts (e.g., Robein Silt). Accreted soils may rest on deposits of any age; it is the surface defined at the top that places them within a particular soil-stratigraphic unit.

Soil-stratigraphic units are not placed in a hierarchy of rank, even though the degree of development, depth of profile, degree of mineral alteration, and other characteristics vary widely. Each soil unit is a separate entity. Where two buried soils converge, each is considered individually as long as the top of each is clearly identifiable.

Morphostratigraphy

A classification category for surficial deposits based on their surface form and called morphostratigraphic units was proposed by Frye and Willman in 1960 (p. 7) and the idea was elaborated in a note of the American Commission on Stratigraphic Nomenclature (Frye and Willman, 1962). A morphostratigraphic unit was defined as comprising a body of rock that is identified primarily from the surface form it displays; it may or may not be distinctive lithologically from contiguous units; it may or may not transgress time throughout its extent. A comparison of the map (fig. 6) showing the distribution of the dominantly till rock-stratigraphic units with the map (pl. 1) showing the distribution of the moraines in the northeastern sector of the state shows the added detail that morphostratigraphic units make available. Furthermore, units of this type, although not defined as such, have been in use in Illinois for more than three quarters of a century (e.g., Leverett, 1899a) as a general Pleistocene classification, and they appear on many geologic maps. Therefore, these units are needed in addition to rock-stratigraphic and time-stratigraphic units.

To be useful, morphostratigraphic units must be clearly differentiated from physiographic units or topographic features that are recognized and named only as land forms. Terraces serve to illustrate this distinction. A terrace has been defined as a relatively level, narrow plain, usually with a steep front, that lies below the general upland level. Such a definition tells us nothing of the sediments below the surface. Some terraces are entirely erosional, controlled by differing competencies of the local bedrock, by the former position of a graded stream on a higher level, or by a former lake level stand. Only if the terrace surface is underlain by alluvial sediments, the deposition of which produced the surface, are we concerned with it as a stratigraphic entity. The deposits under the surface are not otherwise a morphostratigraphic unit. The term "Alluvial Terrace" is appropriately applied to the deposits under such a surface when they are distinguished from other lithologically similar deposits by their genetic relation to the terrace surface.

In Illinois, morphostratigraphic classification is most extensively used to subdivide the glacial deposits, largely of Woodfordian age, in the northeastern sector of the state. In this region, topographic ridges have been recognized for nearly 100 years as moraines produced by the action of

continental glaciers. As detailed studies were made, the deposits related to each episode of moraine building were described and mapped. In formalizing this long-established practice, a "Drift" is defined as deposits of glacial till and outwash associated with a moraine and traceable from it into the groundmoraine, outwash apron, and beneath younger drifts. Thus a named drift extends as far as the genetic relation of the deposits to the land form can be established. Such units generally have limited geographic extent, often are limited to single lobes or sublobes of glacial advance, and may range somewhat in age from place to place. The boundaries of some drifts coincide with a boundary of a rock-stratigraphic unit, although many do not. In places, a rock-stratigraphic boundary may cut across the boundary of a drift.

When morphostratigraphic units were introduced, the term "moraine" was used, in its broad sense, as a name for the unit. Because the term moraine is commonly applied only to the end moraine, this usage was confusing. We now recommend that the earlier term "Drift," capitalized to designate a formal unit, be used for these morphostratigraphic units.

Groups of closely associated moraines that in places cannot be differentiated are called morainic systems, following Leverett (1897). The deposits of a morainic system are also called a drift (Bloomington Drift), or drifts when referring to more than one subdivision. Drift is capitalized only when used with a geographic name.

The general usage of drift, uncapitalized, is not changed. Drift includes glacial and meltwater sediments within the area covered by the glaciers. It does not include the sediments of glacial rivers outside the glaciated area, nor does it include the loess.

Time Stratigraphy

Time-stratigraphic units are units of rock so ordered and defined that they can serve as a calendar for earth history. The units of this classification meet, without gap or overlap, in such a way as to encompass geologic time, and they thus furnish a time scale for the stratigraphic units in all other classifications (fig. 1). The classification of geologic time is directly derived from time-stratigraphic units. Each unit is defined from a column of rocks, based on a type locality — preferably one where the upper and lower boundaries can be described at sharply recognizable contacts, which thus serve to establish time planes that can be widely correlated. Unlike units of a solar or lunar calendar, time-stratigraphic units may be of widely variable lengths, and they provide a hierarchy of units, from large to small, as follows:

Time stratigraphy	Geologic time	Example
Erathem	Era	Cenozoic
System	Period	Quaternary
Series	Epoch	Pleistocene
Stage	Age	Wisconsinan
Substage	(time)	Woodfordian

In Illinois classification, the Quaternary System contains only one series, the Pleistocene, which is divided into eight stages, two of which contain substages. The system is the fundamental unit. A complete sequence of smaller units is not required, although in the Pleistocene Series we recognize a complete sequence of stages.

The time-stratigraphic classification is independent of other classification schemes, but at type sections the boundaries of the Pleistocene units are generally placed at the boundaries of rock-stratigraphic or soil-stratigraphic units. Time planes defined for time-stratigraphic units rarely are physically traceable over wide distances, and therefore all available means of time correlation are used. Traditionally, paleontology is the most generally used means of correlating these time planes, but, in the Pleistocene Series of the Midwest, paleontology is of minimal value in this regard. Soil-stratigraphic units are used widely in correlating time planes, and radiocarbon dates are extensively used for the youngest part of the Pleistocene.

The most significant elements of time-stratigraphic units are the bounding planes.

To serve the intended purpose, the position of a boundary is accurately established at the type locality and from there is correlated laterally as a time plane, regardless of its cutting across units in any other classification system. The problem, of course, is that of establishing time equivalence laterally away from the type, and for that reason boundaries should be chosen that have the best possibility of lateral correlation.

For clarity, all time-stratigraphic names are given adjectival endings (e.g., Sangamonian), whereas all terms in other classifications are written as nouns. For example, in rock stratigraphy we have Berry Clay Member, in morphostratigraphy Bloomington Drift, and in soil stratigraphy Sangamon Soil.

The Pleistocene was a period of rapid and strong climatic oscillations, and some workers have attempted to use climatic change as the sole basis of time correlation. Although climatic changes through time are indeed helpful in this regard, climate varies with latitude, altitude, and general environment at any given time. In the latest part of Pleistocene time, the abundant radiocarbon dates are criteria for establishing time equivalency.

Throughout the classification presented in this report, an attempt has been made to define these boundaries at positions where silts are in contact with the top of a buried soil, because these contacts are the most readily traceable and the least time-transgressive planes available. However, where a boundary is placed at a contact with glacial till, it is not the time-transgressive base of the till that is being correlated, but the time plane defined by the contact at the type locality. In practice, the position of a time plane is placed at its best approximation of time equivalency with the type locality.

ROCK STRATIGRAPHY

For the practical applications of geology — construction, water supply, excavations, waste management, mineral resources studies, and the like — it is necessary to deal with the surficial deposits of the state on the basis of their physical characteristics, to identify and map the different types of rock units, and to understand their variations and interrelations. Rock-stratigraphic classification serves this purpose. Willman, Swann, and Frye (1958, p. 5) said:

> Rock-stratigraphic units are defined and recognized on the basis of observable lithology without necessary regard to biological, time, or other types of criteria. They are sufficiently distinctive to be recognized by common field and subsurface methods. . . . The objective of rock-stratigraphic classification is the recognition of significant lithologic changes in the rock sequence that may be used to establish a framework for stratigraphic description, for geologic and structural mapping, and for various economic purposes.

The A.C.S.N. Code (1961, p. 649) stated:

> A rock-stratigraphic unit is a subdivision of the rocks in the earth's crust distinguished and delimited on the basis of lithologic characteristics. . . . Rock-stratigraphic units are recognized and defined by observable physical features rather than by inferred geologic history.

To be useful a rock-stratigraphic classification must accommodate, at the formation rank, all of the deposits of the state.

This report presents a classification whereby all Pleistocene deposits in Illinois may be placed within a formation (fig. 1). In parts of the stratigraphic sequence, and for some geographic regions, formations have been subdivided into formally defined members. At present there seems to be no need to define groups consisting of several formations. As the need arises in future work, further subdivisions or groupings can be made.

Most of the following descriptions of the formations and members are brief and

general. For more detailed information, 21 described stratigraphic sections are included with this report (table 6), and others are cited from previous literature (table 7). Although part of the present nomenclature is not used in the previously published stratigraphic sections, the rock-stratigraphic unit referred to is readily identified. Tables 2, 3, 4, and 5 show results of analyses for grain-size, clay minerals, carbonate minerals, heavy minerals, and color; voluminous analytical data may also be found in previous publications.

Grover Gravel

The Grover Gravel (Rubey, 1952), named for Grover, Missouri, is well exposed in the overburden of clay pits south of U. S. Highway 50, 2 miles west of Grover, SE NW SW Sec. 3, T. 44 N., R. 3 E., St. Louis County, Missouri (Willman and Frye, 1958). The type section exposes 1 to 3 feet of loess overlying 40 feet of the Grover Gravel and 20 feet of Pennsylvanian shale. In the type section the Grover Gravel consists of four units (from the base):

(1) 20 feet of sand and gravel, well bedded, red and clayey at the top, tan-brown, less clayey and loose in the lower part (samples P-3081, bottom; 3082, top). (2) 9 inches of sand, silt and clay, gray to pink-tan (samples P-3083 to 3086). (3) 15 feet of sand and gravel with a matrix of red clay and sand; contains cobbles and boulders to 1 foot in diameter; clay streaks in middle (samples P-3087 to 3089). (4) 4 feet of sand and gravel, gray, cobbly; contains a few boulders; sharp contact at base (sample P-3090).

The name "Grover" was applied by Rubey (1952) to the brown chert gravel and associated red sand that occur on upland surfaces in the type area and in Calhoun County, Illinois. In that region the gravel truncates Pennsylvanian and older bedrock formations and was deeply weathered and eroded before deposition of the Loveland Silt of Illinoian age.

In this report the Grover Gravel is extended to include many isolated deposits of similar composition and stratigraphic position that occur north of the Shawnee Hills of southern Illinois. In the glaciated area the deposits are overlain and partially truncated by Kansan and younger drifts. They have been called Lafayette, Lafayette-type, or Tertiary gravel. The brown chert gravel in extreme southern Illinois that also has been called Lafayette Gravel differs in the character, color, type, and shape of chert pebbles, and it has a contrasting heavy mineral suite. It is assigned to a new formation, the Mounds Gravel. North of Illinois similar gravel is generally called Windrow Gravel (Thwaites and Twenhofel, 1920; Andrews, 1958). The Grover Gravel is classified as a formation.

The Grover Gravel consists of noncalcareous, dominantly subangular light brown chert pebbles with abundant small, well rounded quartz pebbles, a few purple quartzite pebbles, and a very few pebbles of coarsely micaceous clay that appear to be weathered igneous rocks. The matrix is tan to red quartz sand with a small percentage of feldspar. The heavy minerals of the sand are dominantly zircon and tourmaline; the minerals typical of glacial sands — hornblende, garnet, and epidote — are scarce to absent (table 4). The gravel is as much as 40 feet thick in the type locality, but it is generally less than 10 feet thick, and in many areas it is represented only by a thin line of pebbles between the loess and the bedrock.

The gravel at Grover, Missouri, and north of Golden Eagle, Calhoun County, Illinois, contains boulders of purple quartzite that are almost certainly derived from the Precambrian Baraboo Quartzite of Wisconsin; some are 2 feet in diameter, which seems to require glacial transportation. The local presence of a few weathered igneous pebbles of northern derivation also favors glacial origin. The position of the gravel on the highest upland surfaces, which were deeply dissected before Kansan glaciation, restricts the deposits, if Pleistocene, to a very early glacial age. As previously noted, the gravel conceivably can be the product of a glaciation earlier

than the type Nebraskan. Therefore, we at present assign the Grover to a Pliocene-Pleistocene age.

The gravel is similar in appearance and composition to the Hadley Gravel Member of the Baylis Formation of Cretaceous age in Adams and Pike Counties (Frye, Willman, and Glass, 1964). Some deposits that have been assigned to the Grover Gravel may, in fact, be the Hadley Gravel; others may be Tertiary in age and result from the reworking of the Hadley Gravel; and still others may be the product of reworking during Pleistocene time.

Chert gravel deposits that are now included in the Grover Gravel have been described in several reports (Fenneman, 1910; Horberg, 1946b, 1950b, 1956; Lamar and Reynolds, 1951; Leighton and Willman, 1949; Rubey, 1952; Salisbury, 1892; Wanless, 1957; Willman and Payne, 1942).

Mounds Gravel (New)

The Mounds Gravel consists of the brown chert gravel and associated red sand that occur south of the Shawnee Hills of southern Illinois. It is named for Mounds, Pulaski County, part of which is on a ridge underlain by the Mounds Gravel. The type section is an exposure in a gravel pit 3 miles west of Mounds, SW SW SW Sec. 7, T. 16 S., R. 1 W., Pulaski County, described as the Cache Section (table 6). The Mounds Gravel is classified as a formation.

The deposits included in the Mounds Gravel have previously been called Orange Sand, Lafayette Gravel, Lafayette-type Gravel, Tertiary, Plio-Pleistocene, Continental Deposits, and other names (Amos, 1967; Finch, 1966; Fisk, 1944, 1949; Horberg, 1950a; Leighton and Willman, 1949; Olive, 1966; Potter, 1955a, 1955b; Pryor and Ross, 1962; Ross, 1964; Salisbury, 1891a; Salisbury, *in* Stuart Weller et al., 1920; J. M. Weller, 1940).

In southern Illinois the Mounds Gravel has commonly been related to three terrace surfaces—the upper, called Karbers Ridge, Ozark, Calhoun, Lancaster, or Williana, at an elevation of 580 to 620 feet; the middle, called McFarlan, Central Illinois, Bentley, or Smithland, at 450 to 500 feet; and a lower terrace, called Elizabethtown, Montgomery, or Havana, at 380 to 400 feet. In addition, gravel similar in composition occurs locally at the level of the Ohio River — for instance, at Ft. Massac State Park at Metropolis, Massac County, at an elevation of about 300 feet. The gravel at all these levels is almost identical in character, except for local differences in coarseness. The validity of the terraces as separate erosional benches, capped by gravel generally less than 20 feet thick, is open to question. The middle and upper terraces may be part of a single alluvial fan (Potter, 1955a); in places the benches may be erosional on the gravel; and in other places the apparent relief may be the result of post-gravel warping.

The gravel is composed dominantly of medium to dark brown chert pebbles, most of which are considerably rounded, and some even well rounded. Completely angular pebbles are scarce. Well rounded quartz pebbles, most of them less than half an inch in diameter, are abundant. The lithology and mineral composition of the deposits has been described in detail elsewhere (Lamar and Reynolds, 1951; Potter, 1955a).

Although the Mounds Gravel is nearly continuous in the area south of the Cache Valley, it is represented only by scattered pebbles north of the valley, except in the upland bordering the Mississippi Valley south of Thebes (Pryor and Ross, 1962). Similar gravel also has been observed on top of the Shawneetown Hills (Butts, 1925). In the region from Mountain Glen, Union County, south to Elco, Alexander County, the dominantly light gray chert gravel with a kaolinite clay matrix that contains dark gray and black chert pebbles and abundant quartz pebbles is correlated with the Tuscaloosa Gravel of Cretaceous age, as are similar finer gravels in the same area that are made up largely of small quartz pebbles.

The Mounds Gravel is derived largely from the Tennessee Valley. However, the gravel near the Mississippi Valley west of the Cache Valley and south of Thebes contains the purple quartzite, jasper, and agate that occur in the Grover Gravel and were derived from the Precambrian rocks of the Lake Superior region. The Mounds Gravel contains much higher percentages of kyanite and staurolite than the Grover Gravel, and its chert pebbles are darker brown and more polished.

The Mounds Gravel truncates Paleozoic, Mesozoic, and Tertiary formations, the youngest of which in Illinois is the Eocene Wilcox Formation in the vicinity of Cairo. Farther south the gravel truncates Pliocene sediments and therefore is Pliocene or younger. The gravel at all levels is overlain by the Illinoian Loveland Silt, and it was weathered and deeply eroded before deposition of the loess. Because the gravel lacks the characteristic mineralogy of glacial outwash and was deposited before the deep channels of the Mississippi and Ohio Rivers were eroded, it generally has been assigned a Teritary age. However, the Tennessee Valley source of most of the gravel in southern Illinois can account for the lack of glacial mineralogy. Also, as previously noted, evidence in the Upper Mississippi Valley, although limited, suggests that deep valley incision followed the Nebraskan glaciation and may, in fact, have been initiated by Nebraskan glaciers' establishing the course of the Mississippi River across the Shawnee Hills. In view of these uncertainties, it is preferable to consider the Mounds Gravel as Pliocene-Pleistocene in age.

Enion Formation (New)

The Enion Formation is named for Enion, Fulton County, and the type section is the Enion Section (table 6), an exposure in a ravine half a mile west of Enion, NW SW SE Sec. 32, T. 4 N., R. 3 E., Fulton County, originally described by Wanless (1929b; 1957, fig. 51, geol. sec. 62). The Enion Formation is also described in the Zion Church Section in Adams County (table 6). The Enion Formation includes the glacial tills, outwash, and intercalated silts occurring below the base of the Banner Formation or the top of the Afton Soil; it overlies bedrock formations or the Grover Gravel. Exposures of the Enion Formation are known in a relatively small number of localities in central western Illinois. In most of these the till is distorted, and the quantity so small that there is no assurance that the till has not been transported. The high-level outwash gravels of Jo Daviess County (Willman and Frye, 1969) are also included within the formation.

Deposits that might possibly be assigned to the Enion Formation have been described in other areas in Illinois, but the correlations at present are considered questionable and most of the deposits are included in the Banner Formation. These include the drift called Nebraskan(?) in De Witt, McLean, and Livingston Counties (Horberg, 1953) and in Vermilion County (Eveland, 1952). Later examination of an exposure thought to include till of Nebraskan age near Winchester, Scott County (Bell and Leighton, 1929), indicated that the lower till was Kansan rather than Nebraskan (G. E. Ekblaw, personal communication). Gravel resting on bedrock and overlain by the Banner Formation in Fulton and adjacent counties (Wanless, 1957) contains a few igneous pebbles and may be of the same age as the Enion, but it is dominantly chert gravel and is included in the Grover Gravel.

The Enion Formation is Nebraskan in age. It was deposited by glaciers that advanced from the Keewatin center across Minnesota and Iowa and invaded western and northwestern Illinois (fig. 5).

Banner Formation (New)

The Banner Formation is named for Banner, Fulton County, Illinois, from exposures in the Tindall School Section (table 6), a large borrow pit in the Illinois Valley bluff, SW SW NE Sec. 31, T. 7 N., R. 6 E., Peoria County. The Banner Formation includes the glacial tills and intercalated outwash of sand, gravel, and

silt overlying the Enion Formation or the Afton Soil. It is bounded at the top by the Petersburg, Loveland, Pearl, or Glasford Formations or the top of the Yarmouth Soil. At many places it rests directly on bedrock. The Banner Formation is defined on the basis of its occurrence in western Illinois, but the geographically separate and stratigraphically equivalent deposits elsewhere in Illinois are also included within the formation. The geographic extent of the Banner Formation where it is the surface drift is shown in figure 6, but in the subsurface it is present locally throughout much of western, central, and eastern Illinois in the area covered by the Kansan glaciers (fig. 5). The formation is as much as 300 feet thick where it fills deep valleys in the bedrock, but it was entirely removed by glacial erosion throughout large areas.

In addition to the Tindall School Section, the Banner Formation is described in the Enion and Zion Church Sections (table 6). Other significant sections of the Banner Formation in western Illinois include the Big Creek, Big Sister Creek, Independence School, Little Mill Creek, Mill Creek (Adams County), Mill Creek (Rock Island County), and Pryor School (table 7). Representative sections of the Banner Formation of east-central Illinois are the Georgetown School, Jewett, Petersburg Dam, Rock Creek Township, Taylorville Dam, and Vandalia Bridge Sections (table 7).

Clay mineral data for the Banner Formation of western Illinois are given in table 5 and averages of heavy and light mineral analysis in table 4. The strong contrast in typical clay mineral composition and garnet-epidote ratios between the western and eastern areas of the Banner Formation are shown by table 2. General compositional data have been published (Willman, Glass, and Frye, 1963, 1966; Johnson, 1964; Jacobs and Lineback, 1969; Frye, Willman, and Glass, 1964).

In western Illinois the till of the Banner Formation can be distinguished from the overlying tills of the Glasford Formation by its much higher content of expandable clay minerals, lower ratio of garnet to epidote, and higher ratio of calcite to dolomite, in addition to its stratigraphic position. In east-central Illinois, the clay mineral composition of the till of the Banner Formation falls within the range of that of the overlying Glasford Formation tills, although it is generally somewhat higher in kaolinite and chlorite and lower in expandable clay minerals; the Banner also differs from the Glasford in its higher garnet to epidote ratio and its much higher ratio of calcite to dolomite.

In previous reports the Banner Formation has been called Kansan till, Kansan drift, or pre-Illinoian drift (Cady, 1919; MacClintock, 1926, 1929, 1933; Wanless, 1929a, 1957; Horberg, 1953, 1956; Willman, Glass, and Frye, 1963; Johnson, 1964; Jacobs and Lineback, 1969; and others).

The bulk of the Banner Formation is not subdivided into members, but in western Illinois the Harkness Silt Member occurs at the base and the accretion-gley at the top is the Lierle Clay Member. In central Illinois two members are recognized that occur largely in the subsurface as outwash filling earlier valleys — the Sankoty Sand Member and the Mahomet Sand Member.

In western Illinois fossiliferous silt within the till (Tindall School Section, table 6) has not been found widely enough to justify differentiation as a member. Johnson, Gross, and Moran (in press) differentiated three members in the Banner Formation in the Danville region, Vermilion County.

The Banner Formation extends through the Kansan and Yarmouthian Stages. The deposits are largely the result of glacial advances into Illinois from the northwest and from the northeast.

Sankoty Sand Member

The Sankoty Sand was named by Horberg (formally in 1950a; in abstract 1946a) for its presence in wells in the Sankoty water-well field along the Illinois River

Fig. 6 — Areal distribution of the dominantly till formations and members of Illinois.

on the north side of Peoria, Peoria County. The type section is in a well in NW SE Sec. 15, T. 9 N., R. 8 E., Peoria County. The Sankoty Sand is classified here as a member of the Banner Formation.

The Sankoty Sand occurs in the deepest part of the Ancient Mississippi Valley and adjacent parts of the major tributaries. It averages about 100 feet thick, but locally may be as much as 300 feet thick. It consists largely of medium- and coarse-grained sand and is distinguished from other outwash sands by an abundance of pink quartz grains, many of which are highly polished. It contains little silt and clay. Some beds are pebbly, but gravel is not common.

The Sankoty Sand is overlain by tills of the Banner Formation, except where the till was eroded, which is common, and in places it is overlain by Illinoian or Wisconsinan formations. It rests directly on bedrock formations.

Horberg (1953) considered the Sankoty Sand to be of Nebraskan age, but it is not known to have a soil on it where it is overlain by Kansan age till, and it is more likely pro-Kansan outwash. It probably is present almost continuously in the deep part of the Ancient Mississippi Valley throughout Illinois, and it may extend to the Gulf Coast. The basal Pleistocene sand, called the Natchez Formation, at Natchez, Mississippi, contains polished pink sand grains like those in the Sankoty.

The Sankoty Sand has been described by Horberg (1950a, 1953), MacClintock and Willman (1959), McComas (1968), and Walker, Bergstrom, and Walton (1965).

Mahomet Sand Member

The Mahomet Sand Member was named by Horberg (formally 1953; in abstract 1946a) for Mahomet, Champaign County, near which it is encountered in numerous wells (Horberg, 1953, wells 155, 156, 157, pl. 1, section J-J′). The Mahomet Sand is classified here as a member of the Banner Formation. It occupies the same stratigraphic position as the Sankoty Sand Member, but it consists of about equal amounts of sand and gravel, contains many silt beds, and lacks the polished pink quartz grains that distinguish the Sankoty. It is as much as 150 feet thick.

The Mahomet Sand Member occurs in the Mahomet Bedrock Valley (Horberg, 1945, 1953), mainly in De Witt, Macon, Piatt, and Champaign Counties, but it probably extends eastward into Indiana. Horberg considered the Mahomet Sand to be Nebraskan in age because of possible Nebraskan-age till along the north side of the lower Mahomet Valley, but the presence of Nebraskan drift in the valley has not been confirmed, and it appears more likely that the Mahomet Sand is pro-Kansan outwash. The Mahomet Sand has been described and the position of the valley somewhat modified in reports by Heigold, McGinnis, and Howard (1964), Manos (1961), Walker, Bergstrom, and Walton (1965), Piskin and Bergstrom (1967), and Stephenson (1967).

Harkness Silt Member (New)

The Harkness Silt Member of the Banner Formation is named for Harkness Creek, Adams County. The type section is the Zion Church Section (table 6) 2 miles southeast of Marblehead, SE SE SW Sec. 9, T. 3 S., R. 8 W. At this locality the member is exposed in a roadcut adjacent to a tributary to Harkness Creek and is about 6 feet thick. It consists of massive, calcareous, gray and tan silt with some fine sand. It rests on the Afton Soil developed in outwash and it is overlain by till of the Banner Formation of Kansan age. The mineral composition of the silt (table 5) indicates a northwestern source.

The Harkness Silt Member is also present in the Havana region, where it was called early Kansan silt if bedded and pro-Kansan loess if massive and loess-like (Wanless, 1957). Wanless also noted the local presence of leached, dark greenish gray silt overlying bedrock and overlain by Kansan till, or in a few places by Illinoian till. The age of these silts is questionable. They have been called Aftonian or Yarmouthian according to the age of the overlying till. As they generally occupy the position of the

Harkness Silt, they are included at present in the Harkness, pending more detailed study and differentiation.

The Harkness Silt Member is early Kansan in age. It originated as a pro-glacial silt deposited in front of the Kansan glacier advancing from the northwest.

Lierle Clay Member (New)

The Lierle Clay Member of the Banner Formation is named for Lierle Creek, Adams County, Illinois, and the type section is in roadcut exposures, the Lierle Creek Section (Frye and Willman, 1965a, bed 5, p. 107), in the SE corner SW Sec. 33, T. 1 S., R. 6 W. It is also well exposed 5 miles east in roadcuts, SW SE SE Sec. 32, T. 1 S., R. 5 W., Adams County. The member is exposed at many places in the area where Kansan age drift is the surface drift (pl. 2).

The Lierle Clay Member consists of the accretion-gley that locally overlies the tills of the Banner Formation. In this report it is described in the Zion Church Section (table 6), and a clay mineral analysis is given in table 5. Analytical data on the accretion-gley have been published (Willman, Glass, and Frye, 1966). It is a gray, massive, montmorillonitic, leached clay, with some silt and sand and a few dispersed small pebbles, and it rarely exceeds 10 feet thick. It is bounded at the base by till of the Banner Formation, and at the top by Loveland or Petersburg Silt, the Glasford Formation, or younger deposits.

In age, the Lierle Clay Member is Yarmouthian and locally also late Kansan. It is the product of slow accumulation of sediments, moved by sheetwash and possibly also by wind action, in poorly drained situations on the surface after the retreat of the Kansan glaciers. The sediments accumulated in a soil-forming environment that was intermittently wet, and the entire deposit is considered an accreted soil.

Petersburg Silt

The Petersburg Silt was named in 1963 (Willman, Glass, and Frye) for Petersburg, Menard County. It is classified as a formation. The type section is a roadcut (supplemented by an auger boring) at the south edge of the city and is called the Petersburg Section (table 6), NW NW NE Sec. 23, T. 18 N., R. 7 W. The silt rests on the Yarmouth Soil and is overlain by till of the Glasford Formation of Illinoian age.

The Petersburg Silt was previously included in the Loveland Loess (Leighton and Willman, 1950; Wanless, 1957). In this report it is separated from the Loveland by a vertical cutoff at the outer limit of till in the Glasford Formation. This relation is shown diagrammatically in figure 7.

The formation consists of gray to yellow-tan to purplish tan, calcareous silt with some fine sand and clay. The upper part is generally massive and loess-like, but the lower part is distinctly bedded in places. It commonly contains fossil snail shells.

The Petersburg Silt is described in the Petersburg Dam, Pryor School, Rock Creek Township, and Rushville (2.4 W) Sections (table 7), and in other stratigraphic sections.

The Petersburg is in the early part of the Liman Substage of the Illinoian Stage. It is a pro-glacial deposit of the advancing earliest Illinoian glacier and includes outwash, loess, and some locally derived sediment.

Glasford Formation (New)

The Glasford Formation is herein named for Glasford, Peoria County, Illinois, which is 2 miles northeast of the type section, the Tindall School Section (table 6), SW SW NE Sec. 31, T. 7 N., R. 6 E., Peoria County. The Glasford Formation includes glacial tills, intercalated outwash deposits, and overlying accretion-gley deposits. It overlies the Petersburg Silt or, in the absence of the Petersburg Silt, rests on the Yarmouth Soil; it is bounded at the top by the Sangamon Soil (fig. 7).

The Glasford Formation is the most widespread formation of glacial origin in Illinois, and its southernmost extent repre-

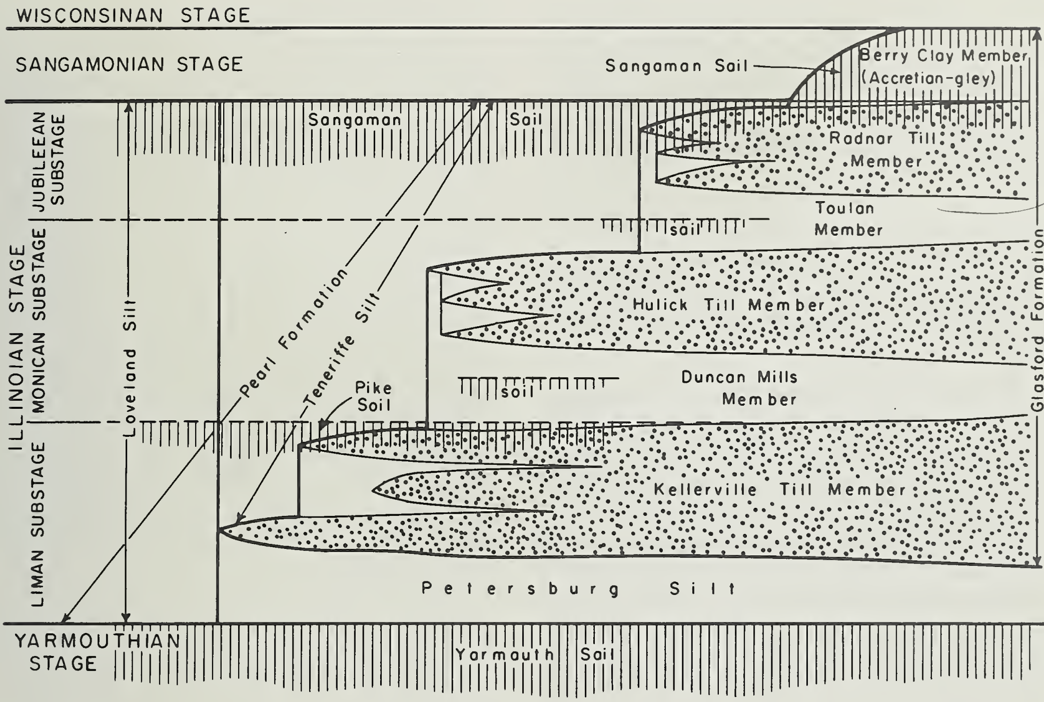


Fig. 7 — Diagrammatic cross section showing the relations of formations and members of Illinoian age in western Illinois.

sents the southern limit of continental glaciers in the northern hemisphere (fig. 5).

In the type section the formation is bounded at the top by the top of the Sangamon Soil developed in till, and at the base by the top of the truncated Yarmouth Soil developed in till of the Banner Formation. The Radnor Till Member, Toulon Member, Hulick Till Member, and the Kellerville Till Member make up the Glasford in the type section. The top of the Glasford Formation is defined as the top of the till and interbedded outwash or the top of the accretion-gley deposits where they overlie the till. The silt deposits overlying the Glasford in some areas, and probably equivalent in age to part of the Glasford, are classed as Teneriffe Silt, and outwash sand and gravel deposits occurring on the Glasford and extending beyond the limit of glaciation are classed as the Pearl Formation. Where the silt or the sand and gravel intertongue with the Glasford Formation, the formations are separated by vertical cutoff. These spatial relations are shown diagrammatically in figure 7, and the geographic extent of the formation is shown in figure 6. It is the formation underlying the loess in most of the area mapped as Illinoian drift on plate 2.

In addition to the type section, other stratigraphic sections in table 6 that describe the Glasford Formation are Chapin, Cottonwood School, Enion, Farm Creek, Flat Rock, Jubilee College, Lewistown, New Salem Northeast, Petersburg, Pleasant Grove, Pulleys Mill, Rochester, Toulon, and Washington Grove Sections.

The matrix grain-size and clay mineral compositions of the tills of the formation are given in tables 2 and 5, and heavy mineral analyses are summarized in table 4. In the laboratory, the tills of the Glasford Formation can be readily distinguished from the tills of the underlying Banner Formation in western Illinois by their higher illite and dolomite content and their higher

ratio of garnet to epidote among the heavy minerals; in eastern Illinois the Glasford Formation is characterized by its higher dolomite content and slightly lower ratio of garnet to epidote among the heavy minerals (table 2). The Glasford Formation tills are not so easily differentiated from the overlying tills of the Winnebago and Wedron Formations by laboratory analysis, but the difference is generally clearly apparent on the basis of physical stratigraphy and soils.

The Glasford Formation has previously been called Illinoian till or Illinoian drift and is described in many reports, of which the following are representative of various areas (Leverett, 1899a; Leighton, 1923a, 1959; Wanless, 1929a, 1957; Lamar, 1925a, 1925b; Ball, 1952; Horberg, 1953, 1956; Leighton and Brophy, 1961; Willman, Glass, and Frye, 1963; Frye, Willman, and Glass, 1964; Johnson, 1964; Frye et al., 1969; Jacobs and Lineback, 1969).

Subdivision of the Glasford Formation into members differs in various regions of the state. In northern Illinois the Sterling, Winslow, and Ogle Till Members are differentiated, in central and western Illinois the Berry Clay, Radnor Till, Toulon, Hulick Till, Duncan Mills, and Kellerville Till Members, and in south-central Illinois the Roby, Hagarstown, Vandalia Till, Mulberry Grove, and Smithboro Till Members. The central and western Illinois members are new, and the others, previously differentiated as informal units, are accepted here as formal members. In extreme southern and southeastern Illinois no subdivision into members has as yet been proposed, but the Berry Clay Member is present locally throughout the extent of the Glasford Formation. Within the formation, the Pike Soil and a minor unnamed soil have been recognized.

The Glasford Formation includes all but the earliest part of the Illinoian Stage, and all of the Sangamonian Stage. It is largely the deposit of glaciers of the Lake Michigan Lobe, but the drift in the southeastern and southern part of Illinois was deposited by the Erie Lobe.

Berry Clay Member (New)

The Berry Clay Member of the Glasford Formation is named for Berry, Sangamon County, and the type section is a roadcut exposure, the Rochester Section (table 6) 3 miles west of Berry, NW SE NW Sec. 34, T. 15 N., R. 4 W. The member consists of gray accretion-gley of clay, silt, and sparse small pebbles and is commonly 2 to 5 feet thick. It rests on till and is overlain by loess. The composition and origin of the deposit have been intensively studied at the type section and throughout central Illinois (Frye, Willman, and Glass, 1960; Frye and Willman, 1963b; Willman, Glass, and Frye, 1966). In earlier reports it was generally called "Illinoian gumbotil" (Leighton and MacClintock, 1930, 1962).

As the deposit is an accreted soil, the Berry Clay Member is included as part of the Sangamon Soil. The Berry Clay Member may overlie the Sterling, Radnor, Hulick, Vandalia, or other members of the Glasford Formation, and is overlain by Roxana Silt, Robein Silt, Peoria Loess, or the Wedron Formation. Other notable exposures of the Berry Clay Member are described in the Coleta, Effingham, Funkhouser East, Hipple School, Panama-A, and Rapids City B Sections (table 7).

The time span of the member, although largely Sangamonian, may range from late Illinoian to early Wisconsinan.

NORTHERN ILLINOIS MEMBERS

Ogle Till Member

The Ogle Till Member of the Glasford Formation was informally named the Ogle tills for Ogle County from exposures in western Ogle County (Frye et al., 1969, p. 24). It is herein formally named a member. The Haldane West Section, NE NE NE Sec. 25, T. 24 N., R. 7 E., Ogle County, was designated the type section. The Ogle tills were described as including three distinctly different till compositions and intercalated outwash of gravel, sand, and silt.

The geographic extent of the member is shown in figure 6, and its composition is summarized in table 2. Despite its range in mineral composition, the till of the Ogle Member is generally sandy, silty, tan to gray-brown, and interstratified with sand and gravel, characteristics that aid in distinguishing it from the more clayey, gray, compact till of the Sterling Till Member that overlies it. At some places the Ogle Till contains the Sangamon Soil in its top, and at many places it is overlain by Roxana Silt (Lanark Southeast, Lanark West Sections, table 7). At a few places the Ogle Till overlies the Kellerville Till Member, but more commonly it rests on bedrock or on a residual soil developed in bedrock. It has been intensely eroded and generally is less than 20 feet thick. Further subdivision of the Ogle Member would appear to be appropriate when more data are available. Although a definite age assignment of the Ogle Till has not been made, it is judged to be in the Monican Substage of the Illinoian Stage.

Winslow Till Member

The Winslow Till Member of the Glasford Formation was informally named the Winslow till (Frye et al., 1969, p. 25) for Winslow, Stephenson County. It is herein formally named a member. The type section is in roadcuts west of Winslow, SW SE SW Sec. 21, T. 29 N., R. 6 E., where 12 feet of dark gray clayey till, the upper 3 feet of which is leached, is exposed. The geographic extent of the Winslow Till Member is shown in figure 6, and its typical composition is given in table 2. The till of the Winslow Member is distinguished from the till of the Ogle Member that partly surrounds it by its much higher clay content and gray color. It is generally less than 20 feet thick. Its stratigraphic relations are not adequately known, but its placement within the Glasford Formation is made on the basis of the Sangamon Soil that occurs above it. It may be still another lithologic variant of the Ogle, or it may be a stratigraphic equivalent of the Sterling Member, but, in either case, it has a distinctly different composition and should be treated as a distinct member. The Winslow Till is commonly bounded at the base by bedrock or by a residual soil developed in bedrock. Its age is not firmly established, but it is judged to be in either the Monican or Jubileean Substages of the Illinoian Stage.

Sterling Till Member

The Sterling Till Member of the Glasford Formation was informally named the Sterling till (Frye et al., 1969, p. 25) for Sterling, Whiteside County. It is herein formally named a member. The type section is the Emerson Quarry Section (Frye et al., 1969, p. 34) 2 miles west of Sterling, SE NW SE Sec. 13, T. 21 N., R. 6 E. It is the uppermost till member of the Glasford in the region north of the Green River Lobe and is similar in clay mineral composition to the Radnor Till Member, which occupies the same stratigraphic position south of the Green River Lobe. Both have an extremely high illite content. The Sterling Member is as much as 40 feet thick in the vicinity of Sterling, but it generally is thinner. The geographic extent of the Sterling Till Member is shown in figure 6, and its typical composition is given in table 2.

The upper boundary of the member is the top of the Sangamon Soil, or, locally, the base of the accretion-gley of the Berry Clay Member (e.g., Red Birch School, Coleta Sections, table 7). It is overlain in some places by the Winnebago Formation, the Robein Silt, the Wedron Formation, or the Peoria Loess, and it overlies the Ogle Till Member or older units. The Sterling Till Member is classed within the Jubileean Substage of the Illinoian Stage.

WESTERN AND WEST-CENTRAL ILLINOIS MEMBERS

Kellerville Till Member (New)

The Kellerville Till Member of the Glasford Formation is named for Kellerville, Adams County, from roadcut exposures 2 miles southwest of Kellerville in the Washington Grove School Section (table 6), NW NW SW Sec. 11, T. 2 S., R. 5 W. It re-

places the terms Mendon Till (Frye, Willman, and Glass, 1964; Frye et al., 1969) and Payson Till (Leighton and Willman, 1950; Wanless, 1957).

The member consists of till with intercalated discontinuous zones of sand and gravel outwash and silt; it is more variable than the overlying tills and commonly has a significantly higher percentage of expandable clay minerals. It is as much as 150 feet thick in the deeper bedrock valleys, but it more commonly is 50 to 100 feet thick. Its geographic extent is shown in figure 6, its spatial relationship is indicated diagrammatically in figure 7, the grain-size and clay mineral composition of the matrix is given in tables 2 and 5, and the average of heavy mineral analyses is given in table 4.

The Kellerville Till is bounded at the base by the Petersburg Silt or, in its absence, by the top of the Yarmouth Soil. Its upper limit is the top of the Pike Soil (New Salem Northeast, Pleasant Grove Sections, table 6), the Duncan Mills Member, the Teneriffe Silt, or younger stratigraphic units. The Kellerville Till is also described in the Cottonwood School, Enion, and Tindall School Sections (table 6). The member is in the upper part of the Liman Substage of the Illinoian Stage. The till was deposited by the westernmost extension of the Lake Michigan Lobe.

Duncan Mills Member (New)

The Duncan Mills Member of the Glasford Formation is named for Duncan Mills, Fulton County, from exposures in the Enion Section (table 6) 4 miles south of Duncan Mills, NW SW SE Sec. 32, T. 4 N., R. 3 E. In the type section the Duncan Mills Member consists of glacially derived sand, and sand and gravel with some silt, generally deeply weathered. It is bounded by the Hulick Till Member above and the Kellerville Till Member below, and is recognized as a member only when it is contained between these two bounding till units. It is also described in the Cottonwood School, Lewistown, and Tindall School Sections (table 6). Clay mineral composition is given in table 5. The Duncan Mills Member is as much as 30 feet thick and has previously been called Jacksonville-Buffalo Hart deposits (Wanless, 1957).

The Duncan Mills Member locally contains deposits in both the Monican and Liman Substages of the Illinoian Stage. It contains outwash of the retreating Kellerville glacier and deposits of the advancing Hulick glacier.

Hulick Till Member (New)

The Hulick Till Member of the Glasford Formation is named for Hulick School, 1.5 miles southwest of the type section, which is in roadcut exposures at the Lewistown Section (table 6), SW SE SE Sec. 21, T. 5 N., R. 3 E., Fulton County. The Hulick Member overlies the Duncan Mills or Kellerville Members. It is bounded at the top by the Toulon, Radnor Till, or Berry Clay Members, the Teneriffe Silt, or Pearl Formation; locally, in the absence of these units, the Sangamon Soil is developed in the top of the member. In addition to the type section, the Hulick Till is described in this report in the Chapin, Cottonwood School, Enion, Jubilee College, and Tindall School Sections (table 6).

The member consists of till and intercalated sand and gravel outwash that is locally over 100 feet thick in the Table Grove Moraine and in some deep bedrock valleys, but it more commonly is about 50 feet thick. The geographic distribution of the Hulick Till Member is shown in figure 6, its spatial relations are indicated diagrammatically in figure 7, the matrix grain size and clay mineral composition are given in tables 2 and 5, and the average of heavy mineral analyses is given in table 4.

The Hulick Till in part of western Illinois was called Buffalo Hart in previous reports (Wanless, 1957). The Hulick is in part stratigraphically equivalent to the Vandalia Till Member of south-central Illinois, but, as its composition is somewhat different and the equivalence of its boundaries has not been established, they are considered as separate members.

The Hulick Till Member is within the Monican Substage of the Illinoian Stage. The till was deposited by a glacier of the Lake Michigan Lobe.

Toulon Member (New)

The Toulon Member of the Glasford Formation is named for Toulon, Stark County, from exposures in a borrow pit three quarters of a mile west of Toulon, NW NW SW Sec. 24, T. 13 N., R. 5 E., described in the Toulon Section (table 6). It consists of glacially derived sand, gravel, and silt, and is bounded above by the base of the Radnor Till Member and below by the top of the underlying Hulick Till Member; it can be identified as a member only when it occurs between these two till members. It is 5 to 10 feet thick, but, as it has not been widely recognized, it probably is much thicker in some areas.

In the Jubilee College Section (table 6) the member consists of calcareous, gray silt and fine sand at the top, overlying a weakly developed unnamed soil in the top of sand and gravel outwash, which in turn unconformably overlies the Hulick Till. The uppermost silt may be a stratigraphic equivalent of the Roby Silt of east-central Illinois, but this has not as yet been confirmed. Compositional data for the Toulon Member are given in table 5.

As the minor soil in the upper part of the member is the boundary of two substages, the bulk of the lower part of the member is in the Monican Substage, but the upper silts are in the Jubileean Substage of the Illinoian Stage. The lower, outwash part of the member is judged to be retreatal outwash, whereas the local silts at the top are pro-glacial deposits in front of the advancing glacier that deposited the overlying Radnor Till Member.

Radnor Till Member (New)

The Radnor Till Member of the Glasford Formation is named for Radnor Township, Peoria County, from roadcut exposures described in the Jubilee College Section (table 6), SW SW SW Sec. 7, T. 10 N., R. 7 E. In the type section the Radnor Till is bounded at the top by the top of the Sangamon Soil. It is overlain by Roxana Silt and it rests on the Toulon Member.

The Radnor Till is gray, compact, silty, and high in illite content. Its geographic distribution is shown in figure 6, its spatial relations are shown diagrammatically in figure 7, its matrix grain size and composition of clay minerals are given in tables 2 and 5, and its heavy mineral analyses are summarized in table 4. It is also described in the Farm Creek, Tindall School, and Toulon Sections (table 6).

The Radnor Till Member may be a stratigraphic equivalent of the Sterling Till Member of northern Illinois but is geographically separated from it by the Green River Lobe. It is in the Jubileean Substage of the Illinoian Stage and was deposited by the Lake Michigan Lobe.

SOUTH-CENTRAL ILLINOIS MEMBERS

Smithboro Till Member

The Smithboro Till Member of the Glasford Formation was informally named the Smithboro till by Jacobs and Lineback (1969, p. 9) in the south-central Illinois region. It was named for Smithboro, Bond County, 5 miles west of the type locality, the Mulberry Grove Section (Jacobs and Lineback, 1969, p. 21), in borrow pits along Interstate Highway 70, SW SW Sec. 31, T. 6 N., R. 1 W., Fayette County. The till is more silty than the Vandalia Till above and is higher in expandable clay mineral content. At the type section it is overlain by the Mulberry Grove Silt. Its character and composition have been described by Jacobs and Lineback (1969).

As the Smithboro is the lowest till member of the Glasford Formation in south-central Illinois, it may be equivalent to the Kellerville Till Member, which is the lowest till unit of the Glasford in western Illinois. However, the tills have slightly different compositions, and separate names seem desirable until they are more directly traced between the two regions.

The Smithboro Till is in the Liman Substage of the Illinoian Stage. Till fabric studies (Lineback, in press) suggest that the glacier advanced from the north, which indicates a source in the Lake Michigan Lobe.

Mulberry Grove Silt Member

The Mulberry Grove Silt Member of the Glasford Formation was informally named the Mulberry Grove silt by Jacobs and Lineback (1969, p. 12) in the south-central Illinois region. It was named for Mulberry Grove, Bond County, and the type locality is the Mulberry Grove Section (Jacobs and Lineback, 1969, p. 21) in borrow pits just east of Mulberry Grove along Interstate Highway 70, SW SW Sec. 31, T. 6 N., R. 1 W., Fayette County. It is a thin, lenticular unit generally less than 1.5 feet thick, consists mostly of calcareous silt, and locally contains a few fossil snail shells and lenses of sand and gravel.

The Mulberry Grove Member is overlain by the Vandalia Till and underlain by the Smithboro Till Member. It appears to occur at approximately the same stratigraphic position as the Duncan Mills Member of central western Illinois. The Mulberry Grove Silt probably is within the early part of the Monican Substage of the Illinoian Stage.

Vandalia Till Member

The Vandalia Till Member of the Glasford Formation was informally named the Vandalia till by Jacobs and Lineback (1969, p. 12) for the south-central Illinois region. It was named for Vandalia, Fayette County, and the type locality is the Vandalia Bridge Section (Jacobs and Lineback, 1969; MacClintock, 1929), NW NE SE Sec. 16, T. 6 N., R. 1 E. It is a relatively sandy, gray, compact till, and the mineral composition has been described by Jacobs and Lineback (1969). It is commonly 25 to 50 feet thick, but it is probably much thicker in some of the deep valleys.

The Vandalia overlies the Mulberry Grove Silt, or the Smithboro Till in the absence of the Mulberry Grove Silt. Where the two tills are in contact, the sandy till of the Vandalia can be readily differentiated from the silty till of the Smithboro. The Vandalia Member is overlain by the Hagarstown Member or the Roby Member, and where these are absent the Sangamon Soil is developed in its top.

The Vandalia Till is judged to be equivalent in part to the Hulick Till Member of western Illinois. Its extent has not been determined, but it probably is the surface till throughout most of the area of Illinoian drift in southeastern Illinois.

The Vandalia Till Member is within the Monican Substage of the Illinoian Stage. In the Vandalia area, the till fabric suggests deposition by a glacier advancing from the northeast, probably part of the Lake Michigan Lobe (Lineback, in press). Its dolomite-calcite ratio is not as high as is typical for the Lake Michigan Lobe nor as low as is usual for the Lake Erie Lobe, which suggests a source in the Saginaw Lobe.

Hagarstown Member

The Hagarstown Member of the Glasford Formation was informally named the Hagarstown beds by Jacobs and Lineback (1969, p. 12), for the south-central Illinois region. It was named for Hagarstown, Fayette County, 5 miles west of the type section, the Hickory Ridge Section (Jacobs and Lineback, 1969, p. 20), SW NW Sec. 30, T. 6 N., R. 1 E., Fayette County. It consists of gravelly till, poorly sorted gravel, well sorted gravel, and sand. It is probably more than 100 feet thick in some of the higher ridges.

The Hagarstown Member lies stratigraphically above the Vandalia Till and contains the Sangamon Soil at the top. It is commonly overlain by Wisconsinan loesses. In surface expression the Hagarstown Member is the material of the elongate ridges, referred to as the "ridged drift," and of the sheet of dominantly waterlaid sediments between the ridges. Its geographic distribution, origin, and

composition have been described by Jacobs and Lineback (1969).

The Hagarstown Member is in either the early Jubileean or late Monican Substage of the Illinoian Stage.

Roby Silt Member

The Roby Silt Member of the Glasford Formation was named the Roby Silt by Johnson (1964, p. 8) in the region of Sangamon and adjacent counties in central Illinois. It was named for Roby, Christian County, and the type section is the Roby Section (Johnson, 1964, p. 35), NW SE NE Sec. 14, T. 15 N., R. 3 W., Sangamon County. The unit consists of silt, clay, and sand, locally contains a fauna of fossil mollusks, and is locally as much as 13 feet thick. Its character and extent have been described by Johnson (1964).

The Roby Member occurs below the Radnor Till Member and above the Vandalia Till Member of the Glasford Formation. The member is recognized only where it is bounded by these two tills. Its position below the Radnor Till suggests that the Roby Member is stratigraphically equivalent to the silt in the upper part of the Toulon Member of central western Illinois, which is exposed in the Jubilee College Section (table 6).

The Roby Silt is in the earliest part of the Jubileean Substage of the Illinoian Stage. It is a pro-glacial deposit of the advancing glacier that deposited the Radnor Till, and it was subsequently overridden by that glacier.

Loveland Silt

The Loveland Silt was named the Loveland joint clay by Shimek in 1909 for Loveland, Iowa, from deposits in the bluff of the Missouri River Valley east of the town. The type locality is listed by Kay and Graham (1943, p. 64) as Sec. 3, Rockford Township, T. 77 N., R. 44 W., Pottawattamie County, Iowa. Shimek described the deposit as reddish to yellowish silt and clay, occurring stratigraphically above the Kansan Till and below loess now correlated with the Roxana. Kay and Graham (1943) reviewed the history of the term and its expansion to include the sand and gravel deposits below the silt. Lugn (1935) restricted the Loveland Formation to the silts above his "Upland" Formation and below the loess of his Peorian Formation. Condra, Reed, and Gordon (1950) restricted the Loveland Formation of Nebraska, across the Missouri Valley from the type section, to the silts above the waterlaid sands and gravels and below the Peorian Loess. Frye and Leonard (1951) assigned the silts and sands above the outwash gravels to the Loveland, and Reed and Dreeszen (1965) restricted the Loveland Loess of Nebraska to the uppermost Illinoian silt deposits.

In Kansas, the term Loveland Member of the Sanborn Formation (Frye and Leonard, 1952) was applied to the silts and loess above the Yarmouth Soil that are terminated at the top by the Sangamon Soil. In Illinois, the term Loveland Loess was applied by Leighton and Willman (1950) to the loess at the base of the Illinoian sequence (now Petersburg Silt), as well as to the silts beyond the limit of Illinoian glaciation, but Frye and Willman (1960) restricted the Loveland Silt to the undifferentiated silts of Illinoian age beyond the Illinoian glacial limit, with its lower boundary the top of the Yarmouth Soil and the upper boundary the top of the Sangamon Soil. The Loveland Silt is classified here as a formation.

The spatial relations of the Loveland are shown diagrammatically in figure 7. The silts intercalated with the tills of Illinoian age are separately named and described, and the Loveland is terminated by vertical cutoff.

In Illinois the Loveland Silt is widespread as the basal unit of the loess sequence in the unglaciated areas of extreme southern Illinois, in Calhoun County and parts of Pike and Jersey Counties in western Illinois, in northwestern Illinois, and also in the area of Kansan glaciation in western Illinois (pl. 2). In these areas it is a distinctive red or red-brown silty

clay or clayey silt, commonly 2 to 4 feet thick but absent or only locally present in many exposures. The Loveland Silt is described in the Cache, Gale, and Zion Church Sections (table 6). Although it locally contains sheetwash and alluvial silts, the major part of the Loveland is judged to be an eolian deposit.

Pearl Formation (New)

The Pearl Formation, named here for Pearl, Pike County, consists of sand and gravel that has the Sangamon Soil in its top. It overlies Illinoian or older drift or bedrock. The type section is an exposure in a box canyon 1 mile southwest of Pearl, SE SW NE Sec. 16, T. 7 S., R. 2 W., Pike County (Frye and Willman, 1965a, p. 14, Pearl Prairie Section, units 1-4). In the type locality the Pearl Formation is a deposit along the front of the Mendon Moraine where the Illinoian glacier mounted the west bluff of the Illinois Valley and blocked drainage from the upland to the west. It is largely a pebbly sand about 40 feet thick with beds dipping steeply southwest, and it appears to be an ice-front delta.

The Pearl Formation is Illinoian outwash, but it may include Kansan outwash in some deep valleys. The formation is restricted to the outwash that overlies or extends beyond Illinoian till. Sand and gravel in the till and intratill members of the Glasford Formation may be continuous into the Pearl Formation, but in nomenclature they are separated from it by a vertical cutoff (fig. 7). Deposits in the same stratigraphic position that are dominantly silt and clay are assigned to the Teneriffe Silt. The Pearl and Teneriffe are never superimposed and are separated by vertical cutoff. Intertonguing and gradational units are described in informal facies classification.

The Pearl Formation has essentially the same lithologic variations as the Wisconsinan Henry Formation, but the subdivisions are not widely enough distributed to merit classification as members. The deposits are generally more oxidized than those of the Henry Formation, but their differentiation is based largely on the presence of the Sangamon Soil in the top of the Pearl, or, when the Sangamon Soil is missing, the presence of the Roxana Silt above the Pearl.

The Pearl Formation most commonly occurs in terraces along valleys near the margin of Illinoian glaciation, except in the major valleys where the surface of Illinoian aggradation was lower than the Wisconsinan and the Illinoian outwash is buried or eroded. The Pearl Formation is also present as outwash on the Illinoian till plain, mainly in front of Illinoian moraines and in isolated kames and crevasse deposits. In the complex relations of the Kaskaskia ridged drift, the outwash is not readily differentiated and is included along with the youngest till in the Hagarstown Member of the Glasford Formation.

Illinoian outwash sands and gravels assigned to the Pearl Formation are described by Frye et al. (1969, Mt. Carroll South Section); Frye and Willman (1965a, Marcelline and Lost Prairie Sections); and Shaffer (1956, Hazelhurst and Mt. Carroll Sections).

Teneriffe Silt (New)

The Teneriffe Silt is herein named for Teneriffe School, 2.5 miles northeast of New Salem, Pike County, and the type section is the New Salem Northeast Section (table 6), described from roadcuts three quarters of a mile southwest of Teneriffe School, NW NE SW Sec. 11, T. 4 S., R. 4 W. It is classified as a formation. In the type area it rests on the Pike Soil developed in Kellerville Till (Liman Substage of Illinoian Stage), and its upper boundary is the top of the Sangamon Soil, developed in the silts; it is overlain by the Roxana Silt. The term is not used beyond the limit of Illinoian glaciation, as beyond this limit comparable deposits are included within the Loveland Silt (fig. 7).

The Teneriffe is largely silt, but it contains beds of sand and clay. It is generally leached, because it contains the San-

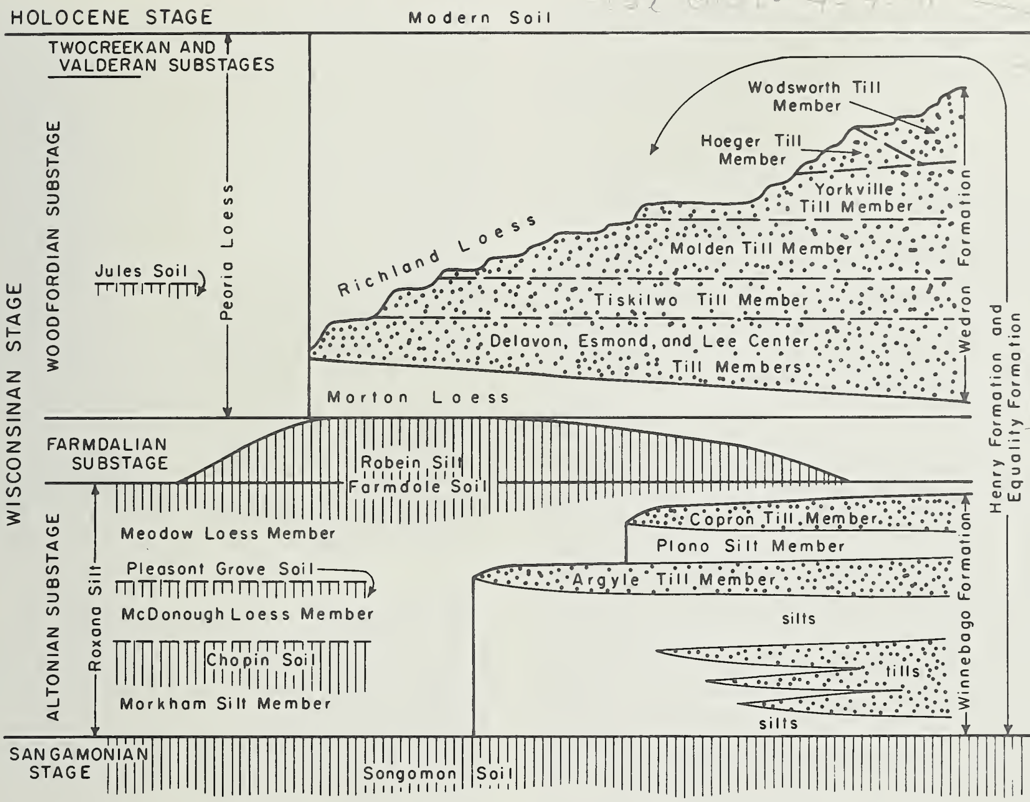


Fig. 8 — Diagrammatic cross section showing the relations of formations and members of Wisconsinan age in northern and western Illinois.

gamon Soil in the top, but it is calcareous in the lower part at a few places where it is thick (e.g., the Pleasant Grove Section, table 6). It is massive and ranges from gray to tan-brown.

The Teneriffe Silt includes deposits that range from latest Liman Substage through the Monican and Jubileean Substages of the Illinoian Stage. It may contain both retreating and advancing outwash of the Illinoian glaciers, as well as sheetwash and some eolian deposits.

Roxana Silt

The Roxana Silt is named for Roxana, Madison County (Frye and Willman, 1960), and the type section is the Pleasant Grove School Section (table 6), a borrow pit in the bluff of the Mississippi Valley 4 miles southeast of Roxana, SW NE SE Sec. 20, T. 3 N., R. 8 W. The Roxana Silt rests on the top of the Sangamon Soil and its upper limit is the top of the Farmdale Soil or the Robein Silt, Morton Loess, or Peoria Loess (fig. 8). It is classified here as a formation.

The Roxana Silt is largely loess, but it locally contains some sand, and commonly the basal unit is colluvium of silt, sand, and clay. It is pinkish tan to yellow-gray. Where it is thick it contains fossil snails, and the fauna has been described (Leonard and Frye, 1960). The Roxana Silt is described in many of the stratigraphic sections included here (table 6) and in previously published sections (table 7). Mineral analyses (table 5) and radiocarbon dates (table 1) are listed, and the spatial relations of the formation are shown diagrammatically in figures 8 and 14. The mineral composition of the Roxana was

extensively described in 1962 (Frye, Glass, and Willman), and its sediment source, as indicated by mineral composition, was discussed in 1968 (Glass, Frye, and Willman).

Where the overlying organic-rich Robein Silt is missing, and it is rarely present outside the area of Woodfordian glaciation, the Roxana Silt is equivalent to the Late Sangamon Loess of earlier reports (Leighton, 1926b; Smith, 1942) and Farmdale Loess (Leighton, *in* Wascher, Humbert, and Cady, 1948; Leighton and Willman, 1950).

The Roxana Silt contains distinctive zones differentiated largely by color (Frye and Willman, 1960), and it was divided into five informal zones, Ia, Ib, II, III, and IV (Frye and Willman, 1963b). It is herein divided into three members, the Markham at the base (zone Ia of earlier usage), terminated upward by the top of the Chapin Soil; the McDonough (zone Ib of earlier usage) next above the Markham, terminated by the top of the Pleasant Grove Soil; and the Meadow Loess Member (zones II, III, and IV of earlier usage) at the top, terminated by the top of the Farmdale Soil.

The Roxana Silt is of Altonian age.

Markham Silt Member (New)

The Markham Silt Member is named for Markham, a village on the Norfolk and Western Railroad 4 miles west of Jacksonville, Morgan County. Its type section is the Chapin Section (table 6) in roadcuts along Illinois Highway 104, 1.5 miles northwest of Markham, on the west side of Mauvaise Terre Creek, SW NE NW Sec. 8, T. 15 N., R. 11 W. The Markham Member previously was called Roxana Zone Ia (Frye and Willman, 1963b). It is the same as "upper story Sangamon" in recent Iowa literature (Ruhe et al., 1968).

In many places the Markham is a colluvium of silt and some sand with small pebbles, and locally it is entirely within the A-zone and B-zone of the Chapin Soil. Along the Illinois River Valley it commonly contains some loess admixed with the colluvium, and so has a mineral composition different from that of the underlying Sangamon Soil (Frye, Glass, and Willman, 1962; Glass, *in* Frye and Willman, 1965b), but along the Mississippi River Valley its mineral composition is commonly indistinguishable from that of the underlying Sangamon Soil B-zone. Other stratigraphic sections with this report describing the Markham Member are the Campbells Hump, Cottonwood School, Gale, Jubilee College, and Tindall School Sections (table 6). Its mineral composition is given in table 5, and its spatial relations are shown in figure 8.

The Markham Member is in the earliest part of the Altonian Substage of the Wisconsinan Stage.

McDonough Loess Member (New)

The McDonough Loess Member of the Roxana Silt is named for McDonough Lake on the Mississippi River floodplain in Madison County. Its type section is the Pleasant Grove School Section (table 6) 1 mile southeast of McDonough Lake, SW NE SE Sec. 20, T. 3 N., R. 8 W. The McDonough Member, designated Roxana zone-Ib in previous Illinois literature, overlies the Chapin Soil and is terminated at the top by the Pleasant Grove Soil and the overlying Meadow Loess Member of the Roxana Silt.

The McDonough Loess is gray to tan, generally leached, but at a few places (e.g., Pleasant Grove School Section) it contains some etched fossil snail shells. The member is also described in the Chapin, Cottonwood School, and Gale Sections (table 6). Previously published sections that describe the McDonough Member (Roxana zone-Ib) include the De Pue, French Village, Fulton Quarry, Hillview, and Literberry Sections (table 7). The spatial relations are shown diagrammatically by figure 8, and mineral compositions are listed in table 5.

The McDonough Member is in the midpart of the Altonian Substage of the Wisconsinan Stage.

Meadow Loess Member (New)

The Meadow Loess Member of the Roxana Silt is named for Meadow Heights, a northeastern section of Collinsville, Madison County. Its type section is the Pleasant Grove School Section (table 6) three quarters of a mile west of Meadow Heights, SW NE SE Sec. 20, T. 3 N., R. 8 W. It is the uppermost member of the Roxana Silt, and in previous Illinois literature was called zones II, III, and IV of the Roxana Silt (Frye and Willman, 1960, 1963b; Frye, Glass, and Willman, 1962).

This member forms the major part of the Roxana Silt. It rests on the Pleasant Grove Soil developed in McDonough Loess and is terminated upward by the top of the Farmdale Soil or by the Robein Silt, Morton Loess, or Peoria Loess.

The Meadow Loess is a uniform silt and the three zones are based largely on color, pinkish tan in the lower and upper parts and gray to gray-tan loess in the middle. Although the zones have gradational contacts, they are distinct in the area of thick Roxana Loess from Havana, Mason County, to Gale, Alexander County, more than 250 miles. They become less distinct as the loess thins back from the bluffs and are rarely recognizable more than 15 miles from the bluffs. The mineral composition of the loess is given in tables 4 and 5, its spatial relations are shown diagrammatically in figure 8, and radiocarbon dates are listed in table 1. Its character is described in many of the stratigraphic sections in this report (table 6).

The Meadow Loess occurs late in the Altonian Substage of the Wisconsinan Stage.

Winnebago Formation

The Winnebago Formation was informally named Winnebago drift (Frye and Willman, 1960) for Winnebago County, as a replacement for the term Farmdale drift (Shaffer, 1956). The term was formalized as a formation in 1969 (Frye et al.), and the type locality was designated as the Rock Valley College Section and adjacent exposures and Northwest Tollway borings No. 2 and No. 5 (Kempton, 1963, p. 38). The type section is in the Rock Valley College Section, SW NW SW Sec. 10, T. 44 N., R. 2 E. It consists of 1.5 feet of Peoria Loess overlying 6 feet of leached till and 7 feet of calcareous, pink, sandy and cobbly till. The till is the Argyle Till Member of the Winnebago Formation. The formation was defined to include those glacial deposits bounded by the Farmdale Soil at the top and the Sangamon Soil at the base. The formation has been described in detail from deep core borings in Kane and McHenry Counties (Kempton, *in* Frye and Willman, 1965a), and its textural and mineral composition has been described (Frye et al., 1969).

The Winnebago Formation consists of tills, silts, peats, and outwash, and it probably is as much as 400 feet thick in the deeper bedrock valleys. It is subdivided into three named members: the Capron Till Member at the top, the Plano Silt Member below the Capron, and the Argyle Till Member below the Plano Silt. In the subsurface below the Argyle are silts, tills, and some outwash that have not been differentiated into members. Radiocarbon dates determined from the formation are listed in table 1, compositional data are given in tables 2, 4, and 5, and the geographic distribution of the formation at the surface is indicated on the map in figure 6. The spatial relation of the Winnebago to adjacent stratigraphic units is shown diagrammatically in figure 8.

The Winnebago Formation is entirely within the Altonian Substage of the Wisconsinan Stage. It is related largely to glacial advances from the Lake Michigan Lobe and possibly the Green Bay Lobe.

Argyle Till Member

The Argyle Till Member of the Winnebago Formation was informally named the Argyle till (Frye et al., 1969, p. 26) for Argyle, Winnebago County, from exposures in the vicinity of Argyle on the Winnebago County line. Its type section is the Rock

Valley College Section 5 miles southwest of Argyle, SW NW SW Sec. 10, T. 44 N., R. 2 E. The Argyle is bounded at the top by its contact with the Plano Silt Member or overlying beds, and its basal contact is with unnamed silts in the lower part of the Winnebago Formation or older deposits.

The till is exceptionally sandy, as shown in table 2, and pinkish tan or salmon in color. Its composition has been described, and its stratigraphic position shown by the Greenway School cores and the Beaverton, Byron West, Dixon Northwest, Grand Detour, and Meridian Road No. 3 Sections (Frye et al., 1969). The geographic distribution as a surface till is shown in figure 6, and the spatial relations are shown diagrammatically in figure 8.

The Argyle Till Member is in the mid-part of the Altonian Substage of the Wisconsinan Stage.

Plano Silt Member

The Plano Silt Member of the Winnebago Formation was named the Plano Silt (Kempton and Hackett, 1968b, p. 31) for Plano, Kendall County. The type section is the Big Rock Creek Section (Kempton and Hackett, 1968b, p. 32), an exposure in the east bank of Big Rock Creek 3.5 miles northeast of Plano, SE NE Sec. 1, T. 37 N., R. 6 E. The Plano Member is bounded above by its contact with the Capron Till Member and at the base by its contact with the Argyle Till Member. The member is also described in Greenway School cores 2 and 4 (Frye et al., 1969).

The Plano Silt consists of silt, organic silt, and peat. Radiocarbon dates determined from the Plano are listed in table 1, and its spatial relations are shown diagrammatically in figure 8.

The Plano is in the later part of the Altonian Substage of the Wisconsinan Stage. It is the product of slow accumulation of silt, loess, and organic matter during the interval of glacial withdrawal between the deposition of the Argyle and Capron Till Members.

Capron Till Member

The Capron Till Member of the Winnebago Formation was informally named the Capron till (Frye et al., 1969, p. 26) for Capron, Boone County, from its occurrence in the prominent ridge that trends north-south through the town. The type section is the Capron North Section, a roadcut 3 miles north of Capron, NE SE SE Sec. 23, T. 46 N., R. 4 E., where 2.25 feet of Peoria Loess overlies 1 foot of leached till, 2 feet of pink calcareous till, and 3.5 feet of calcareous sand. The till and sand are the Capron Member. The Capron Till is bounded at the base by its contact with the Plano Silt Member and at the top by its contact with the Robein Silt or overlying beds.

The Capron has two compositional phases, an upper sandy phase and a lower silty phase. The typical compositions of these phases are indicated in table 2. The geographic distribution of the member is shown in figure 6, and its spatial relations are shown diagrammatically in figure 8. The Capron Member is within the youngest part of the Altonian Substage of the Wisconsinan Stage.

Robein Silt (New)

The Robein Silt is named for the village of Robein, Tazewell County, and its type section is the Farm Creek Section (table 6), NE SW SE Sec. 30, T. 26 N., R. 3 W. The name is a direct replacement for Farmdale Silt (Frye and Willman, 1960). It became necessary to rename the unit because of repeated redefinition of Farmdale (Frye and Willman, 1960; Leighton, 1960), and because the same locality is also the type for the Farmdale Soil and the Farmdalian Substage. The Robein Silt is classed as a formation. It is bounded below by the Roxana Silt or underlying formations and above by Morton Loess or by units of the Wedron Formation.

The Robein Silt consists of silts, sandy silts, organic silts, and peat. It is generally less than 5 feet thick and in many localities is only a few inches thick. Although thin,

the Robein is a widespread and distinctive stratigraphic marker unit in Illinois. It has been extensively radiocarbon dated (table 1), its composition is shown in table 5, and its spatial relations are shown diagrammatically in figures 8 and 14. In this report the Robein is also described in the Campbells Hump Section (table 6), and previously published sections include the Danvers, Fondulac Dam, Perry Northeast, and Richland Creek Sections (table 7). An uncommon phase of the Robein as a slackwater silt is described in the Wedron Section (table 6).

The Robein is largely within the Farmdalian Substage of the Wisconsinan Stage. Although it contains some loess, it consists largely of organic material and locally derived silt deposited by sheetwash.

Morton Loess

The Morton Loess (Frye and Willman, 1960, p. 7) is named for Morton, Tazewell County. The type section is the Farm Creek Railroad Cut Section 6 miles northwest of Morton, center Sec. 31, T. 26 N., R. 3 W. (Frye and Willman, 1960, p. 11). It was formerly called Peorian (Alden and Leighton, 1917; Leighton, 1926b) and later Iowan (Leighton, 1933; Leighton and Willman, 1950). It occurs stratigraphically between the Robein Silt, or Farmdale Soil developed in Roxana Silt below, and the overlying till of the Wedron Formation. It is here classified as a formation.

The Morton is generally a gray to tan, calcareous, massive, fossiliferous silt, bounded by sharp contacts at top and bottom. It is as much as 10 feet thick, but it is generally thinner because of truncation by the Wedron Formation. In this report it is described in the Campbells Hump, Farm Creek, and Malden South Sections (table 6); its composition is indicated in table 5, and its spatial relations are shown in figures 8 and 14.

The Morton Loess is in the earliest part of the Woodfordian Substage of the Wisconsinan Stage. Its upper contact, where not erosional, is time transgressive. In contrast, the base of the loess is more nearly a time plane. The sediments of the Morton were derived from the outwash of the advancing early Woodfordian glacier and reflect the sediment source of those glaciers. When the advancing glacier from the Lake Michigan Lobe blocked the former course of the Ancient Mississippi River, it produced an abrupt change in the clay mineral composition (Glass, Frye, and Willman, 1964) that can be traced as a stratigraphic datum in the Morton and Peoria Loesses of the central Illinois Valley region (Frye, Glass, and Willman, 1968).

Peoria Loess

The Peoria Loess is named for Peoria, Peoria County. The term Peorian loess was introduced by Alden and Leighton in 1917. They applied the term Peorian, originally introduced by Leverett (1898a) as an interglacial term, to the loess deposit previously called Iowan, including the loess below the Shelbyville (Woodfordian) till. Kay and Leighton (1933) established the present usage by restricting Peorian to the loess outside the Shelbyville till and applying the term Iowan (Morton Loess of present classification) to the loess under the till. The name was modified to Peoria loess for use as a rock-stratigraphic unit (Frye and Leonard, 1951), and this form was adopted in Illinois (Frye and Willman, 1960). It is classified as a formation in this report. The history of the terms Peorian and Peoria, as used in Illinois, is shown in figure 13, analytical data are presented in tables 4 and 5 and in previous publications (Frye, Glass, and Willman, 1968; Glass, Frye, and Willman, 1968), and spatial relations are shown in figures 8 and 14.

The Peoria Loess overlies the Farmdale Soil developed in Roxana Loess, Robein Silt, or older units. Outside the area of Woodfordian glaciation the Peoria also overlies the Henry and Equality Formations.

No type section has previously been designated for the Peoria Loess. Leverett referred to exposures along the Illinois Valley in the vicinity of Peoria as evidence for the Peorian Interglacial Substage. We propose

that the Tindall School Section (table 6) be considered the type section of the Peoria Loess. This section is in the west bluff of the Illinois Valley south of Peoria, in Peoria County, and therefore is within the type area originally indicated by Leverett. The Peoria consists of the loess overlying the Farmdale Soil, and it has the Modern Soil in its top.

The Peoria Loess is generally light yellow-tan to gray, fine sandy silt in the bluffs of the source valleys, and it grades to brownish gray clayey silt back from the bluffs (Smith, 1942). Although generally massive, the loess has faint bedding where it is thick in the bluffs, and it locally has lenses of well sorted, medium-grained sand, which are dunes that were buried by loess. As shown on plate 2, the Peoria Loess occurs outside the Woodfordian boundary, and it represents 60 to 80 percent of the total thickness of the loess, the lower part being the Roxana Silt. It has a maximum thickness of about 75 feet, but rarely exceeds 50 feet. Where it is thick in and near the major valleys it contains fossil snail shells. The fauna has been described in many reports by F. C. Baker (see Bibliography) and by Leonard and Frye (1960). The Jules Soil occurs locally in the upper part.

The Peoria Loess is described in many reports, including the following: Leverett, 1899a; Savage, 1916; Leighton, 1926b, 1965; Wanless, 1929a, 1957; Smith, 1942; Leighton and Willman, 1950; Rubey, 1952; Leonard and Frye, 1960; Frye, Glass, and Willman, 1962, 1968; Frye and Willman, 1963b; Glass, Frye, and Willman, 1964, 1968; Fehrenbacher et al., 1965a, 1965b; Frye, Willman, and Glass, 1968. In this report the Peoria Loess is described in the Chapin, Cottonwood School, Flat Rock, Gale, Jubilee College, New Salem Northeast, Pleasant Grove, Pulleys Mill, Rochester, and Zion Church Sections (table 6).

The Peoria Loess spans the Woodfordian Substage of the Wisconsinan Stage, and it locally may contain deposits of Valderan age, or younger, in its uppermost part.

Richland Loess

The Richland Loess is named for Richland Creek, Woodford County (Frye and Willman, 1960). The type section is a roadcut north of the creek, NW SE SW Sec. 11, T. 28 N., R. 3 W., which exposes 6 feet of Richland Loess. The lower 4 feet is calcareous and fossiliferous and overlies 2 feet of sand and gravel (Henry Formation) and 3 feet of calcareous, pink sandy till (Tiskilwa Till Member of Wedron Formation). This loess formerly was identified by age and called Tazewell Loess (Leighton, 1933). It rests on till of the Wedron Formation, and beyond the limit of Woodfordian glaciation (the Wedron Formation) it is equivalent to the upper part of the Peoria Loess.

The unit consists of yellow-tan massive loess and contains the Modern Soil in the top. It has a maximum thickness of 20 feet locally in the Illinois Valley bluffs in Woodford County northeast of Peoria. The thickness of the Richland Loess is shown on plate 3, where all the loess shown within the Woodfordian boundary is Richland. Where it is more than 6 to 8 feet thick in the southern part of the area and where it is more than 4 to 6 feet thick in the northern part, it is calcareous below the soil. The calcareous loess locally contains fossil snail shells (Leonard and Frye, 1960). The Richland Loess has been described by Willman and Payne (1942); Leonard and Frye (1960); Wascher et al. (1960); Frye, Glass, and Willman (1962, 1968); and Glass, Frye, and Willman (1968). In this report, the Richland Loess is described in the Farm Creek, Malden South, and Wedron Sections (table 6). Representative previously published sections include the Buda East, Partridge Creek, Sturdyvin School, Ten-Mile School, Varna South, and Walnut Southeast Sections (table 7). Mineral composition has been reported by Frye, Glass, and Willman (1962, 1968) and in table 5, and spatial relations are shown diagrammatically in figures 8 and 14.

The Richland ranges from middle to latest Woodfordian, and it may locally contain some deposits of Valderan age. The

basal contact of the loess is strongly time transgressing. When traced from the central Illinois River Valley toward the northeast, it rests on progressively younger tills of the Wedron Formation. Wherever the base of the loess is calcareous, the top of the underlying till is also calcareous, indicating that the loess began to accumulate as soon as the ice melted.

Wedron Formation

The Wedron Formation (Frye et al., 1968) is named for Wedron, La Salle County, and the type section is the Wedron Section (table 6) in the Wedron Silica Company pit, SE SW Sec. 9, T. 34 N., R. 4 E. The Wedron Section does not include the uppermost part of the formation, but it is one of the longest and most typical exposures of the formation (Sauer, 1916; Willman and Payne, 1942, fig. 82 and geol. sec. 68; Leighton and Willman, 1953; Leonard and Frye, 1960; Frye and Willman, 1965b).

The formation was defined as comprising those deposits of glacial till and outwash extending upward from their contact on Morton Loess (or on the Robein Silt in the absence of the Morton) to the top of the till below the Two Creeks deposits at Two Creeks, Wisconsin. Although largely till, this span of rocks also contains numerous beds of outwash, including gravel, sand, and silt. The formation is extremely variable in thickness. It is as much as 200 to 250 feet thick in some of the larger moraines, and it probably averages about 100 feet thick.

The Wedron Formation has been described in numerous reports in addition to those already cited, including Leverett, 1897, 1899a; Cady, 1919; Fisher, 1925; Athy, 1928; Leighton and Ekblaw, 1932; Horberg, 1950a, 1953; Horberg, Larson, and Suter, 1950; Bretz, 1955; Suter et al., 1959; Zeizel et al., 1962; Willman, Glass, and Frye, 1963; Piskin and Bergstrom, 1967; Kempton and Hackett, 1968b. In many of these reports the Wedron includes beds identified by an age designation and called Early and Middle Wisconsin, or Tazewell and Cary drift.

The spatial relations of the Wedron Formation are shown diagrammatically in figure 8, geographic distribution in figure 6, and its composition is indicated in tables 2, 3, 4, and 5. Radiocarbon dates from the Wedron Formation, as well as the more abundant dates from above and below it, are listed in table 1.

The Wedron Formation spans all but the earliest part of the Woodfordian Substage of the Wisconsinan Stage. The youngest drift in the formation does not occur in Illinois but is present in Wisconsin and Michigan. The formation was deposited by glaciers of the Lake Michigan and Erie Lobes.

The Wedron Formation of northeastern Illinois is herein divided into the following members, in descending order: Wadsworth Till Member, Haeger Till Member, Yorkville Till Member, Malden Till Member, Tiskilwa Till Member, and the Esmond and correlative Lee Center and Delavan Till Members.

Esmond Till Member

The Esmond Till Member of the Wedron Formation was informally named the Esmond till (Frye et al., 1969, p. 26) from the village of Esmond, De Kalb County. The type section is in roadcuts, NW SW NW Sec. 27, T. 43 N., R. 2 E., Winnebago County, 10 miles north of Esmond, but the till has been studied in detail in the Greenway School cores near Esmond (Frye et al., 1969). The type section exposes about 10 feet of brownish gray, calcareous, clayey till of the Esmond Member overlain by 2 feet of Richland Loess. The underlying pink sandy till of the Winnebago Formation is exposed down the hill 100 yards to the north. The Esmond is also well exposed in the Dixon Northwest and the Grand Detour Sections (table 7). The upper boundary of the member is the pink-tan Tiskilwa Member or equivalent deposits, and the lower boundary is on Morton Loess or deposits of the Robein Silt or Winnebago Formation.

The Esmond Till has two phases, an upper silty phase and a lower silty clay phase,

both of which are characterized by a high illite content (tables 2 and 3). It is gray and contains relatively few cobbles and pebbles. It is a thin drift, generally not more than 20 to 30 feet thick. Its geographic distribution is shown in figure 6.

The Esmond Till is in the early part of the Woodfordian Substage of the Wisconsinan Stage. It was deposited by the Dixon Sublobe of the Lake Michigan Lobe.

Lee Center Till Member

The Lee Center Till Member of the Wedron Formation was informally named the Lee Center till (Frye et al., 1969, p. 26) from the village of Lee Center, Lee County, which is located on the back slope of the Temperance Hill Moraine that marks the northern limit of the till. The type section is a roadcut 5 miles northwest of Lee Center, SE SW NW Sec. 31, T. 21 N., R. 10 E., where 8 feet of calcareous, gray, slightly silty till of the Lee Center Till Member underlies 4 feet of leached, brown Richland Loess. The till has been studied in detail in the Lee No. 3 core boring (Frye et al., 1969). It is bounded at the top by the sharply contrasting pink till of the Tiskilwa Till Member, and at the base it rests on Morton Loess or Robein Silt.

The member is well exposed in the Malden South and Wedron Sections described in this report (table 6) and the Moon School Section in Henry County (table 7). It consists largely of gray clayey till and is generally only 20 to 30 feet thick, except in the Temperance Hill Moraine where it is as much as 50 feet thick. The composition of the till is given in tables 2, 3, and 5, and its distribution is shown on the map in figure 6.

The Lee Center Till is stratigraphically equivalent to the Esmond and Delavan Members but is classed as a separate member because its composition contrasts strongly with that of the Esmond Till Member (table 3) and because of its geographic restriction to the Green River Sublobe of the Lake Michigan Lobe.

The Lee Center Till is in the early part of the Woodfordian Substage of the Wisconsinan Stage. It was deposited by the Green River Sublobe of the Lake Michigan Lobe.

Delavan Till Member (New)

The Delavan Till Member of the Wedron Formation is named for Delavan, Tazewell County. The type section consists of exposures in roadcuts along Illinois Highway 121, 4 miles east of Delavan, SW Sec. 16, T. 22 N., R. 3 W., where 12 feet of Richland Loess, calcareous in the lower part, overlies 10 feet of calcareous gray till of the Delavan Till Member. The Delavan Member is also well exposed in the Danvers Section (table 7). It is bounded at the top by the pink-tan Tiskilwa Till, and it rests on the Morton Loess.

The Delavan is largely gray, silty, illitic till and is as much as 200 feet thick in the Shelbyville Morainic System. Its composition is given in tables 2, 3, and 5.

The Delavan Till presumably is stratigraphically equivalent to the Esmond and Lee Center Till Members, but it differs strongly from the Esmond in composition and is separated from the Lee Center geographically (fig. 6). Like the other two, it is bounded at the top by the overlying Tiskilwa Member and at the base by the Morton Loess.

The Delavan Till is in the early part of the Woodfordian Substage of the Wisconsinan Stage. It was deposited by the Peoria Sublobe of the Lake Michigan Lobe.

Tiskilwa Till Member (New)

The Tiskilwa Till Member of the Wedron Formation is named for Tiskilwa, Bureau County, and the type section is a roadcut, the Buda East Section, SE SE SW Sec. 31, T. 16 N., R. 8 E., 5 miles northwest of Tiskilwa (Frye and Willman, 1965a, p. 95, unit 1). In the type section it is overlain by sand and gravel of the Henry Formation, which is overlain by the Richland Loess.

The till of the Tiskilwa Member is sandy, pink-tan to reddish tan-brown, and generally is described as pink till. It is commonly 100 to 150 feet thick beneath

the higher parts of the Bloomington Morainic System. It is bounded above by the more illitic, tan to yellow-gray Malden Till, and below by gray tills of the Delavan, Esmond, or Lee Center Till Members. Although the basal contact is locally somewhat transitional, the tills below are distinctly less red and are all higher in illite content (table 3). Because of its distinctive pink color, the Tiskilwa Till is widely differentiated in outcrops along the Illinois Valley as far east as Joliet (Fisher, 1925; Willman and Payne, 1942) and in subsurface (Kempton and Hackett, 1968b).

In the stratigraphic sections included with this report, the Tiskilwa Till is decribed in the Malden South and Wedron Sections (table 6). Its composition and color are listed in table 3, its geographic distribution is shown in figure 6, and its relations to other units are shown diagrammatically in figure 8.

The Tiskilwa Till is in the early part of the Woodfordian Substage of the Wisconsinan Stage, and it was deposited by glaciers of the Peoria, Princeton, and Harvard Sublobes of the Lake Michigan Lobe.

Malden Till Member (New)

The Malden Till Member of the Wedron Formation is named for Malden, Bureau County, and the type section is the Malden South Section (table 6) in roadcuts 2 miles south of Malden, SW SE SE Sec. 5, T. 16 N., R. 10 E.

The Malden Till Member consists of silty, locally sandy, yellow-gray to gray-tan till with discontinuous beds of sand and gravel. It is bounded at the top by the darker gray, very clayey Yorkville Till and at the base by the pink Tiskilwa Till. It differs from the Yorkville in having a higher ratio of garnet to epidote (table 4). Data on grain size, clay mineral composition, and color of the matrix of the till are given in table 3, and the geographic distribution is shown in figure 6.

The Malden Till is in the mid-part of the Woodfordian Substage of the Wisconsinan Stage. It was deposited by the Peoria, Princeton, and Harvard Sublobes of the Lake Michigan Lobe.

Yorkville Till Member (New)

The Yorkville Till Member of the Wedron Formation is named for Yorkville, Kendall County. Its type section is a roadcut at the intersection of Illinois Highways 71 and 47, 1 mile south of Yorkville, SE SE SE Sec. 5, T. 36 N., R. 7 E., where 6 feet of typical calcareous, pebbly, clayey till of the Yorkville Till Member is overlain by 2 feet of leached Richland Loess.

The till of the Yorkville Member is a very clayey gray till, slightly darker than the other gray tills, and it commonly has a slight greenish cast. Although the overlying Wadsworth Till is nearly as clayey, the Yorkville is characterized by an abundance of small dolomite pebbles that become concentrated on weathered surfaces and give the till the superficial appearance of gravel. This is more characteristic of the till in the Marseilles Drift than of the tills of the Minooka and younger drifts. The Yorkville Till Member is as much as 200 feet thick below the higher part of the Marseilles Morainic System (Willman and Payne, 1942). The distribution of the member is shown in figure 6. Data on grain size, clay mineral composition, and color of the matrix are given in table 3. Its average composition in comparison with the other tills is given in table 2.

The Yorkville Till Member is in the mid-part of the Woodfordian Substage of the Wisconsinan Stage and was deposited by glaciers of the Peoria, Princeton, and Harvard Sublobes of the Lake Michigan Lobe.

Haeger Till Member (New)

The Haeger Till Member of the Wedron Formation is named for Haegers Bend, a village on the Fox River between Fox River Grove and Algonquin, McHenry County. The type section consists of roadcuts along the Algonquin-Cary Road half a mile northwest of Haegers Bend, NW NE Sec. 23, T. 43 N., R. 8 E. In the type section the Haeger Till Member con-

sists of 12 feet of calcareous, very gravelly, silty, yellow-gray till overlain by 1 to 2 feet of leached Richland Loess.

The Haeger Member is bounded at the top by the clayey Wadsworth Till and at the base by the clayey Yorkville Till. It overlaps onto the pink Tiskilwa Till. Southward it either grades into the outer drift of the Wadsworth Member, which has been the preferred interpretation for many years as shown by the mapping of the West Chicago Moraine through the transition zone (pl. 1), or it is overlapped by the Wadsworth Member south of the area where the Fox River cuts through the West Chicago Moraine.

The Haeger Till Member consists largely of silty, sandy, gravelly till interstratified with sand and gravel outwash, but locally it contains some areas of silty clayey till. It varies greatly in thickness but seems generally to be relatively thin, 20 to 30 feet thick, except in isolated hills in which it is as much as 50 feet thick. The geographic extent of the Haeger Till Member is shown in figure 6. Data on grain size, clay mineral composition, and color of the matrix are given in table 3. Its average composition in comparison with the other tills is given in table 2.

The Haeger Till Member is in the midpart of the Woodfordian Substage of the Wisconsinan Stage and was deposited by the Harvard Sublobe of the Lake Michigan Lobe.

Wadsworth Till Member (New)

The Wadsworth Till Member of the Wedron Formation is named for Wadsworth, Lake County, and the type section is a roadcut at the intersection of Illinois Highway 131 and the Wadsworth Road 2 miles east of Wadsworth, SE SE SW Sec. 30, T. 46 N., R. 12 E., where 6 feet of typical Wadsworth Till (sample P-6982, table 3) contains the thin Modern Soil in its top. The Wadsworth Till consists of the highly clayey, gray tills of the Lake Border Morainic System, the Tinley Moraine, and most of the Valparaiso Morainic System (pl. 1, fig. 6). The tills of the Lake Border Drift are higher in expandable clay minerals and less pebbly than those in the western part of the member. These drifts, particularly the Tinley, contain a conspicuous amount of Mississippian-Devonian black shale pebbles, and minute brown spores from those rocks are common in the till matrix. In general, the Lake Border Drift is more clayey and contains fewer pebbles and coarser materials than the Valparaiso Drift. Its clay minerals include about 10 percent more montmorillonite than those of the Valparaiso.

The Wadsworth Member is adjacent to the sandy and gravelly Haeger Till Member in northern Illinois, but farther south, beyond the limit of the Haeger, it is much less sharply differentiated from the Yorkville Till Member. The outer margin of the Wadsworth is characterized by till that is more silty and contains more gravel lenses than is typical of either the Wadsworth or Yorkville, and it may be a thin southern equivalent of the Haeger. At the top, the member is bounded by its contact with the Lake Michigan Formation.

The geographic distribution of the member is shown in figure 6, and its spatial relations to other members are indicated diagrammatically in figure 8. Data on matrix grain size, clay mineral composition, and color are given in table 3. As shown in table 2, the Wadsworth and Yorkville Tills have the highest clay content of the tills of the Wedron Formation, are high in illite content, and contain more dolomite than calcite.

The Wadsworth Member is the youngest till member in Illinois in the Woodfordian Substage of the Wisconsinan Stage. It was deposited by the Joliet Sublobe of the Lake Michigan Lobe.

Henry Formation (New)

The Henry Formation, named for Henry, Marshall County, consists of glacial outwash that is dominantly sand and gravel and is overlain only by the Richland Loess, post-Wedron formations (fig. 1) or the Modern Soil. Similar deposits that are

overlain by or intertongued with till are included with the till in the Wedron or Winnebago Formations and are separated from the Henry Formation by vertical cut-off (fig. 8). The type section is a gravel pit along Illinois Highway 29, 2 miles north of Henry, SE SE Sec. 32, T. 14 N., R. 10 E., where 30 feet of sand and gravel typical of the Henry Formation is overlain by 1 to 2 feet of Richland Loess and Modern Soil. The formation is also exposed at numerous other places in the broad terrace on which the town of Henry is located.

The formation is present in nearly all counties that were covered by Wisconsinan glaciers, and it extends down many valleys through the Illinoian and older drifts and the unglaciated areas. The formation is highly variable in thickness. In some valleys and in some of the higher kames, the Henry is more than 100 feet thick, but in some outwash plains deposits only a foot or two thick cover large areas. Mineral analyses of sands from the Henry Formation are given in table 4.

Glacial outwash deposits included in the Henry Formation have been described in many reports, the following of which are typical for various parts of Illinois (Anderson, 1960, 1964, 1967; Anderson and Block, 1962; Anderson and Hunter, 1965; Block, 1960; Ekblaw, 1932b, 1962a, 1962b; Ekblaw and Lamar, 1964; Ekblaw and Schaefer, 1960; Eveland, 1952; Fisher, 1925; Hackett, 1960; Lamar and Willman, 1958; Wanless, 1957; Willman and Payne, 1942).

The formation is subdivided into three members differing in lithology as well as origin. The Batavia Member consists of outwash plains, the Mackinaw Member of valley trains, and the Wasco Member of ice-contact deposits. The three members have been widely differentiated in geologic mapping in Illinois, although not previously described as formal stratigraphic units.

The Henry Formation is Wisconsinan in age. Similar sand and gravel outwash deposits are found in the Pearl Formation, which is related to the Illinoian glaciation, but they are deeply weathered and commonly have the Sangamon Soil at the top.

Batavia Member (New)

The Batavia Member of the Henry Formation is named for Batavia, Kane County, which is near the west side of an extensive outwash plain along the front of the West Chicago Moraine. The type exposure is in gravel pits 8 miles north of Batavia, SW Sec. 1, T. 40 N., R. 8 E., where 20 feet of the Batavia Member, consisting of well sorted, regularly bedded gravel, is overlain by 1 to 2 feet of leached brown silt (Richland Loess and Modern Soil).

The Batavia Member is an upland unit deposited largely along the fronts of moraines. In some areas the outer margin of the outwash plain converges into valleys, and the deposits grade into the valley trains of the Mackinaw Member. In general the deposits in the outwash plains vary in degrees of coarseness more rapidly, both laterally and vertically, than the valley train deposits, and their bedding is less uniform. Some outwash plains deposited near the ice front are pitted, have complex structures, and grade into ice-contact deposits of the Wasco Member. A few deposits of outlet rivers from glacial lakes are similar in character and are included in the Batavia Member.

The Batavia Member is Wisconsinan in age.

Mackinaw Member (New)

The Mackinaw Member of the Henry Formation is named for Mackinaw, Tazewell County. The member is well exposed in pits in the terraces along the Mackinaw River Valley. The type section is in a gravel pit on the southwest side of the town of Mackinaw, NE NW Sec. 19, T. 24 N., R. 2 W., where 30 feet of gravel of the Mackinaw Member is overlain by 3 to 5 feet of silt of the Richland Loess that has the Modern Soil at the top.

The Mackinaw Member consists of sand and gravel outwash from the Wisconsinan glaciers that was deposited in the valleys. Remnants of these valley-train deposits are widely present in terraces and beneath the floors of the valleys. Many of the major valleys have had repeated intervals of

filling and cutting, and in them the deposits occur in several terrace levels. Although the deposits in the different terraces may be similar or may differ notably in composition, they are all included in the Mackinaw Member. Differentiation of the terraces is based largely on physiographic expression, and they are morphostratigraphic units—alluvial terraces.

The valley-train deposits of the Mackinaw Member are more evenly bedded and more uniform in texture than the other members of the Henry Formation. Most of the deposits are sandy gravel or pebbly sand, but in some localities, such as along the Illinois Valley between Joliet and Channahon, the gravel is very coarse. Some of the deposits are related to the outlet rivers of glacial lakes rather than to direct discharge from the glaciers. These are included in the Mackinaw Member because of their position in the valleys and the difficulty in many areas of differentiating them from valley-train deposits.

The Mackinaw Member is Wisconsinan in age.

Wasco Member (New)

The Wasco Member of the Henry Formation is named for Wasco, Kane County, which is located on a small kame in the midst of a large kame complex. The type section is in a gravel pit along the Chicago and Great Western Railroad, SE NW Sec. 24, T. 40 N., R. 7 E., and consists of 15 feet of poorly sorted sand and gravel. The member is well exposed in many other small pits in the complex of kames.

The Wasco Member consists of ice-contact sand and gravel deposits, most of them in kames, eskers, and deltas, all characterized by both lateral and vertical variability in grain size, sorting, bedding, and structure. Many of the deposits contain cobbles and boulders. Balls of silt and till and irregular masses or lenses of till are common. Although most abundant in the younger drifts, particularly in McHenry, Lake, Kane, and Du Page Counties, the Wasco Member is present and locally abundant in nearly all counties covered by Wisconsinan glaciers.

The Wasco Member is Wisconsinan in age.

Equality Formation (New)

The Equality Formation is named for Equality, Gallatin County, in the area covered by Lake Saline (fig. 9). The formation is well exposed along the Saline River at Equality, but the type section, the Saline River Section, is an exposure in a recent excavation at a bridge crossing the river 4 miles southwest of Equality, SE corner SW Sec. 27, T. 9 S., R. 7 E. The type section exposes 6 feet of Peoria Loess, the lower 2 feet of which is calcareous and contains calcite nodules. The loess overlies 30 feet of the Equality Formation, which consists of the following units from the top:

Silt, clayey, calcareous, massive, brown-gray (sample P-7109 in middle), 2 feet; silt and silty clay interbedded, gray to light gray, calcareous, that contain fossil snail and clam shells (P-7108), 3 feet; clay, silty, calcareous, gray-brown, bedded (P-7107), 2 feet; silt, clayey, sandy, leached, light yellow-brown (P-7106), 2 feet; silt, leached, dark gray to brown, massive, finely sandy, friable with texture suggestive of crumb structure of a soil A-zone (P-7105), 1 foot; silt, clayey, calcareous, massive, tan-brown at top grading downward to pink-tan at base (P-7104 at top, P-7103 at base), 6 feet; covered by slump to water level, 8 feet.

The character of the formation where it is penetrated by wells near Equality was described by Butts (1925). The Equality Formation consists of deposits in lakes where they are surficial deposits overlain only by loess or Holocene deposits.

The major glacial and backwater lakes in which the Equality Formation was deposited are shown in figure 9. In addition, lacustrine sediments accumulated in hundreds of small lakes on the Woodfordian drift. In many of these lakes the sediments grade upward into peat and the organic-rich deposits are included in the Grayslake Peat. The Lake McKee sediments in Adams County (fig. 9) are Illinoian in age and were deeply weathered before deposition of the Wisconsinan loess. They are included in the Teneriffe Silt

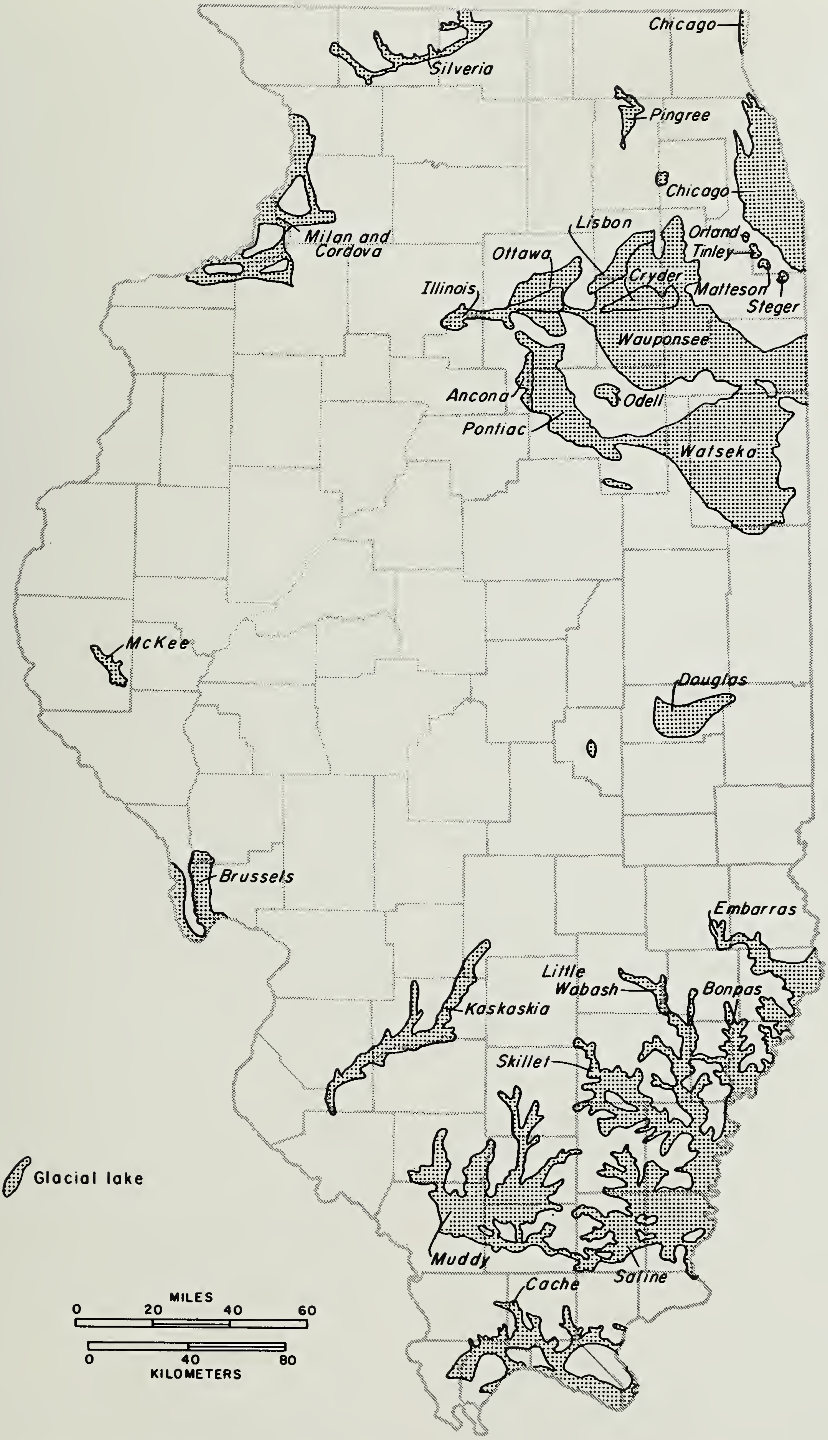


Fig. 9 — Glacial lakes of Illinois. These are the principal areas of the Equality Formation, with the exception of Lake McKee and possibly Lake Brussels. Areas of lakes overridden by glaciers are not shown.

because they are bounded above by the distinctive Sangamon Soil. The Brussels Terrace sediments in Calhoun, Jersey, and Greene Counties (fig. 9) are largely lacustrine and are tentatively assigned to the Teneriffe Silt, but relations to the loess in a few localities suggest that they may belong to the Equality Formation.

Many of the lakes mapped are ice-front lakes formed by the blocking of drainage lines by glaciers. However, the large lakes in the upper Illinois River Valley resulted from waters that spread over the lower areas between the moraines when the outlet along the Illinois River was inadequate to accommodate the exceptionally large volumes of water issuing from the melting Valparaiso glaciers. The large lakes along the Wabash River Valley and its tributaries, the Ohio River Valley and its tributaries, and the Kaskaskia River Valley were slackwater lakes resulting from the aggradation of the major valleys by Wisconsinan valley trains.

The Equality Formation is divided into two members. The Carmi Member consists of the relatively deep-water lacustrine sediments — the finer grained sediments that are largely silt and clay with sand a minor constituent. The Dolton Member consists of the coarser grained sediments, largely sand, pebbly sand, and locally gravel, with minor beds of silt and clay. These are the beaches, bars, spits, and deltas, mainly near-shore sediments. The Dolton Member has a facies relation to the Carmi Member. Where neither type of sediment dominates, the members are not differentiated.

As lacustrine deposits deeply altered by weathering before deposition of the loess are included in other formations, the Equality Formation is restricted to deposits of Wisconsinan age.

Many of the lacustrine deposits included in the Equality Formation have been described (Hershey, 1896d; Shaw, 1911, 1915; Ekblaw, 1931; Bretz, 1939, 1955; Willman and Payne, 1942; Shaffer, 1954a; Gardiner, Odell, and Hallbick, 1966; Anderson, 1968; and others).

Carmi Member (New)

The Carmi Member of the Equality Formation is named for Carmi, White County, which is located on a terrace underlain by lacustrine sediments that were deposited in Lake Little Wabash (fig. 9). The deposits are locally exposed along the Little Wabash River at Winters Bridge 4 miles north of Carmi, but the type section is along Crooked Creek 5 miles northeast of Carmi, NE corner SW Sec. 21, T. 4 S., R. 10 E. The type section exposes 4 feet of red, medium-grained sand of the Parkland Sand on 2 feet of tan-brown, leached silt of the Peoria Loess, overlying 6 feet of the Carmi Member. The Carmi consists of sandy, slightly pebbly, leached clay that is gray in the upper part but mottled brown and black in the lower part. Sample P-7113 is from the top, P-7112 from the middle, and P-7111 from the base. The Equality type section is also typical of the Carmi Member. Typical exposures of the Carmi Member in Lake Chicago and in smaller lakes on the Valparaiso Drift were described by Bretz (1955). The Carmi Member generally consists of well bedded layers of silt and clay with some fine-grained sand. In areas that have thick loess on the surrounding hills, the lacustrine sediments are dominantly massive silt that resembles the loess. The lacustrine silts generally have more clay than the loess.

The Carmi Member is generally less than 20 feet thick, and in many of the lake basins the sediments are less than 5 feet thick. Locally they are more than 50 feet thick (Butts, 1925). In a few lake basins the deposits form an essentially continuous sheet, but in others they were widely eroded soon after deposition so that only remnants remain, and loess rests directly on till over large parts of the lake plains.

Dolton Member (New)

The Dolton Member is named for Dolton, Cook County, part of which is on a beach of the Toleston stage of Lake Chicago. Eight feet of the member, largely sand, is exposed at the top of a clay pit in S½ NE Sec. 3, T. 36 N., R. 14 E.,

Cook County. The member is dominantly sand, with local beds of silt and gravel. In the type locality it has been mapped separately from the fine-grained lake-bottom sediments (Bretz, 1955) that are assigned to the Carmi Member. Although most of it consists of beach and bar sands, the member locally includes pebbly sand and gravel deposits that are ice-front deltas and lag deposits from wave erosion of till.

Cahokia Alluvium (New)

The Cahokia Alluvium is named for Cahokia, St. Clair County, which is located on the floodplain of the Mississippi River in the broad area east of St. Louis that is called the American Bottoms. The type section is in a well (Illinois Geological Survey test hole 2, Bergstrom and Walker, 1956, p. 31-32) 3 miles southwest of Cahokia, 0.8 mile south of the center of East Carondelet. The upper 45 feet is Cahokia Alluvium consisting largely of silt, clay, and clayey sand, with wood and shell fragments, overlying 60 feet of sand and gravel of the Henry Formation, which rests on bedrock. Eight feet of well bedded brown silt at the top of the Cahokia Alluvium is exposed near a bridge crossing Prairie du Pont Creek 3 miles southeast of Cahokia and half a mile east of Stolle, St. Clair County. The Cahokia Alluvium is here classified as a formation. It consists of deposits in the floodplains and channels of modern rivers and streams (fig. 10).

Cahokia Alluvium replaces the long-used term "Recent Alluvium" because (a) the alluvium is a distinctive lithologic unit and should be included in the rock-stratigraphic classification and not named for a time unit; (b) the term Recent is replaced in this report by Holocene, making the change appropriate at this time; and (c) in many valleys only the upper part of the alluvium is of Recent, or Holocene, age.

As the alluvium began to accumulate in many valleys as soon as they were free of ice, the deposits vary in age; some are as old as early Woodfordian. The general character of the alluvium in the American Bottoms has been described by Bergstrom and Walker (1956, p. 17, 28, 30) and in various parts of the state by Butts (1925), Lamar (1925a), Wanless (1929a, 1957), Willman and Payne (1942), Rubey (1952), and others.

The alluvium is dominantly a silty deposit because much of it is derived from erosion of loess and till. Loess was still accumulating in the region when some of the alluvium was deposited. Although lenses of sand and gravel are locally common in the alluvium, these lenses generally have a relatively high silt content. The degree of sorting varies but is generally poor. The major part of the alluvium consists of materials transported down the valley and deposited in the floodplains during intervals of flooding, but it also includes sediments deposited directly by tributary streams. The latter sediments commonly consist of lenses of relatively coarse material intertongued with floodplain silts. In some areas the contributions from the tributary valleys are large, and they accumulate in broad alluvial fans that the major river occasionally floods but does not greatly erode. Alluvial fans 1 to 2 miles wide are prominent features at the mouths of tributary streams in the Illinois Valley. In some places they partly dam the valley, forming lake-like expansions of the river, like Peoria Lake above the alluvial fan at the mouth of Farm Creek at East Peoria. Although common along the Illinois Valley, which has a very low gradient, the fans are smaller and less abundant along the Mississippi Valley, which has a higher gradient. As the fans intertongue with and are not readily differentiated from the floodplain deposits and are continuous with the alluvium in the valley from which they are derived, they are considered part of the Cahokia Alluvium.

The Cahokia Alluvium is present along all Illinois streams (fig. 10), although locally absent in localities where the stream is actively eroding. The thickness varies greatly, but 10 to 20 feet is common along many valleys and 50 to 75 feet is found along major valleys. The present Mississippi River is believed to erode as much as 50 feet deep during flood stages.

Fig. 10 — Generalized map of floodplains of modern rivers and streams of Illinois. Principal areas of Cahokia Alluvium.

In most of Illinois the Cahokia Alluvium is distinguished from older deposits by not having a cover of loess. In some valleys in the unglaciated areas, alluvium of mixed local material occurs on narrow benches above the present floodplain, and these commonly have a cover of loess.

The Cahokia Alluvium generally rests unconformably on bedrock and glacial deposits. In the major valleys, the alluvium generally rests on glacial valley-train deposits of the Mackinaw Member of the Henry Formation. In places where deposition was continuous, the outwash deposits generally are well sorted but the alluvium is poorly sorted. Most valleys, however, were deepened after the outwash was deposited, and the alluvium rests with sharp contact on the glacial or older deposits. Many of the valleys that have floodplains were eroded after glaciation, but probably only the smaller tributaries contain floodplain deposits entirely of Holocene age.

Although the Cahokia Alluvium commonly is in the process of formation, it locally is overlain by Grayslake Peat or Peyton Colluvium, and at a very few places it may be overlain by the Lacon Formation or the Parkland Sand.

The Cahokia Alluvium is Wisconsinan and Holocene in age.

Grayslake Peat (New)

The Grayslake Peat is named for exposures of peat in the pit of the Grayslake Peat Company 1 mile southeast of Grayslake, Lake County, NE SE NE Sec. 2, T. 44 N., R. 10 E. The type section (Hester and Lamar, 1969, p. 12) exposes 14 feet of peat. It is here classified as a formation. It consists for the most part of organic deposits that are covered only by soil or slopewash from surrounding hills. The formation is largely peat and muck, but locally it is partly or largely marl. Many deposits contain interbedded silt and clay.

The Grayslake Peat develops in a swampy depression or in the late stage of lake filling. It overlies lacustrine sediments, outwash, or till. It underlies the flat surfaces of the lake basins and, in places, borders present lakes. Many of the areas are swampy and the deposits still accumulating.

The Grayslake Peat occurs most abundantly in lake basins in the northern part of the Valparaiso Drift in McHenry and Lake Counties, but it is present in nearly all counties in the area of Woodfordian glaciation. It also is present in some filled or partially filled floodplain lakes, particularly along the Illinois Valley below Starved Rock, and in abandoned channels resulting from glacial diversion, such as the Goose Lake Channel in Whiteside County. In these areas it locally overlies the Cahokia Alluvium.

The deposits vary greatly in thickness and some 30 feet thick have been reported. The most detailed maps of the peat deposits are in county reports of the University of Illinois Agricultural Experiment Station. Some of the peat deposits shown on early maps have been drained and, as a result of oxidation, are greatly thinned and changed into organic silts. Some would not now be classified as peat.

The Grayslake Peat is Wisconsinan and Holocene in age.

Lacon Formation (New)

The Lacon Formation, named for Lacon, Marshall County, consists of deposits that are dominantly gravity-initiated, such as landslides, slumps, slips, rock falls, and mudflows. The type section is a landslip area along the base of the bluffs of the Illinois Valley 2 miles northwest of Lacon, E½ Sec. 2, T. 12 N., R. 9 E., described by Ekblaw (1932a). Only those deposits that are surficial or covered by slopewash are included in the Lacon Formation.

Ground water is the lubricating agent for most of the movements that formed the Lacon Formation. The deposits consist of disturbed masses or broken fragments of locally derived rocks. The Lacon Formation varies from deposits in which the source rocks are mixed, such as many talus deposits, to those resulting from mass movements that only slightly disturbed the original materials. If cemented, the deposits

would be called breccia. At some places the deposits of the Lacon Formation grade into or intertongue with the sediments in the Cahokia Alluvium and the Peyton Colluvium, but the formations are separated by vertical cutoff.

The Lacon Formation is Wisconsinan and Holocene in age. Some of the deposits probably were initiated by the rigorous periglacial climate and still continue to accumulate.

Lake Michigan Formation (New)

The Lake Michigan Formation consists of the surficial lacustrine deposits and beach sediments of modern lakes; "surficial" in this case includes the sediments directly underlying the water of the lake.

The major locale of the formation is in Lake Michigan, for which it obviously is named. It is also present in nearly all existing natural lakes. In Lake Michigan the formation overlies either the till of the Wadsworth Member of the Wedron Formation or Paleozoic bedrock. It is overlain only by water, except on the beaches. The youngest till is part of the Lake Border Drift, but in places the lake floor probably is eroded into older drift. A cross section of the sediments along a line from 12 to 32 miles east of Waukegan, Lake County, serves as a type section (Gross et al., 1970). It shows the character of the formation where the water is from 250 to 400 feet deep. In shallower water, particularly in the southern part of the lake, sand and gravel deposits are common. Till or Paleozoic bedrock directly underlies the water at some places, and the Lake Michigan Formation is absent. Sediments within the lake have been described by Hough (1935), Ayers and Hough (1964), and Ayers (1967).

The Lake Michigan Formation is complex and, pending more detailed tracing of various lithologic units, the only member differentiated here is the sand in the present beaches, named the Ravinia Sand Member.

The formation is thin in many of the small lakes that do not receive sediment from streams and is absent in lakes where the sediments are dominantly organic, because such sediments are part of the Grayslake Peat.

The Lake Michigan Formation is Wisconsinan and Holocene in age. The sediments are still accumulating in the lakes, except in localized areas of current or wave scour. However, accumulation began as soon as the lake was formed, which makes the basal sediments in many lakes Woodfordian in age.

Ravinia Sand Member (New)

The Ravinia Sand consists of modern beach sand. A typical segment of the beach of Lake Michigan occurs at Ravinia, the southern part of Highland Park, Lake County, W½ Sec. 31, T. 43 N., R. 13 E. The sands on the present beaches are well sorted, nearly white, and relatively clean compared to sands in the Cahokia Alluvium. They are less iron stained and contain less silt and clay than sands along the shorelines of the glacial lakes that are included in the Equality Formation. The major locale of the Ravinia Sand Member is the beach of Lake Michigan. The character of the sand and the processes involved in its deposition have been described by Atwood and Goldthwait (1908), Needham (1929), Pettijohn (1931), Hough (1935), Lamar and Grim (1937), Bretz (1939), Willman (1942), Krumbein and Ohsiek (1950), Krumbein (1953, 1954), and Johnson (1956). Smaller areas of beach sand are present locally along the shores of many other Illinois lakes.

Parkland Sand (New)

The Parkland Sand consists of windblown sand in dunes and in sheet-like deposits between and bordering the dunes. It is classified as a formation and is named for Parkland, Tazewell County, a small village 3 miles northeast of Manito. The type locality is a roadcut in the edge of the Manito Terrace 5 miles west of Parkland, SW SE SW Sec. 2, T. 23 N., R. 7 W. The roadcut exposes 10 to 20 feet of uniform, well sorted, medium-grained sand typical of the Parkland Formation that overlies 25

feet of pebbly sand and sandy gravel of the Henry Formation. The Parkland Sand is well exposed in shallow roadcuts and scattered "blowouts" among the dunes throughout the Manito Terrace. Grain-size and mineral analyses of the sand have been reported (Willman, 1942; Wanless, 1957).

The Parkland Sand is widespread throughout the northern part of Illinois (fig. 11), and small areas are present in the southern part, most of them along the Wabash River Valley. The dunes are largely on terraces along the major valleys and consist of medium-grained sand sorted by the wind from underlying glacial outwash, which is mostly sand and pebbly sand. In many areas the dunes have migrated onto the bluffs and uplands east of the terraces, in some places as much as 2 or 3 miles inland. Most of the sand is fine grained in the dunes farthest from the source area in the terraces. Dunes 20 to 40 feet high are common; a few are 80 to 100 feet.

The Parkland Sand also occurs along shorelines of glacial lakes where it has been blown from sand of the Equality Formation. Dunes also occur locally on the beaches of Lake Chicago.

Most of the dunes are anchored by vegetation, and some have a thin cover of loess. It appears that many were formed soon after the terraces were free from glacial flooding, and they vary in age from Woodfordian through Holocene.

Peyton Colluvium (New)

The Peyton Colluvium is named for Peyton Creek, which crosses an area of the formation that is mapped as slopewash and alluvial fans (Wanless, 1957) at the base of the Illinois Valley bluffs 1.5 miles southwest of Glasford, NW NE Sec. 32, T. 7 N., R. 6 E., Peoria County. It is here classified as a formation. It includes the widely distributed but narrow belts of poorly sorted debris that accumulated at the base of steep slopes, largely by creep and slopewash. The numerous small alluvial fans and cones that occur at nearly every gully and grade into slopewash deposits are included in the formation. The material is dominantly a pebbly silt, but its composition depends on the material in the bluffs above. Along loess-mantled bluffs it appears to grade upward into loess by decrease in the abundance of pebbles. At its lower margin the colluvium grades or interfingers into the stream or river alluvium, but the Peyton Colluvium is separated from the Cahokia Alluvium by vertical cutoff.

Man-Made Deposits

Deposits made by man, or resulting from the activities of man, occupy large land areas and are mappable units. In many respects they are similar to stratigraphic units. As the number and extent of these deposits is certain to grow, they merit consideration as stratigraphic units. Because of the general requirement that stratigraphic units be natural units, we are considering the man-made deposits as informal units.

Four principal types of man-made deposits are differentiated—(a) made land (the fill in lakes), (b) sediment in man-made lakes and related backwater areas, (c) strip-mine waste piles, and (d) sanitary, rubbish, road, dam, and construction fills, and waste piles of underground mines and industrial operations. All of these types can be subdivided, and there are intermediate types.

The made-land deposits, such as the areas along the shore of Lake Michigan (Bretz, 1943), are largely sand and are made by trapping sand behind piers, by barging and pumping sand, and in part by fill of miscellaneous rock and other debris. The deposits on which Miegs Field, the lake front airport at Chicago, is built are typical.

Sediment in man-made lakes and related backwater areas is largely silt. It does not differ greatly from that in natural lakes, except that most of the larger artificial lakes are along rivers that carry considerable sediment, and the sediments are coarser, contain much woody debris from drowned forests, and have bedding structures indicative of rapid sedimentation. The sediments in Lake Bracken, near

Fig. 11 — Major areas of wind-blown sand in Illinois. Principal areas of Parkland Sand.

Galesburg, Knox County, are typical (Jones, 1937a; Larson et al., 1951b). The sediments in other artificial lakes in Illinois have been described by Brown, Stall, and DeTurk (1947); Glymph and Jones (1937); Jones (1937b); Larson et al. (1951a); Stall et al. (1949, 1951a, 1951b, 1952, 1953); Stall and Bartelli (1959); Stall, Gottschalk, and Smith (1952); Stall and Melsted (1951); and Stall, Rupani, and Kandaswamy (1958).

The strip-mine waste piles consist of mixtures of the deposits that lie over the various mineral deposits quarried. The material is essentially a mixture of the local material, usually both Pleistocene and bedrock materials. The large areas from which coal has been stripped in Grundy County are typical.

The coal strip mines now cover many square miles in some counties and are generally differentiated in geologic mapping. As many of the areas are being restored to a condition difficult to recognize from undisturbed land, accurate mapping is essential for future land evaluation. Waste piles are much smaller and grow more slowly around the pits and quarries that produce other minerals, but areas large enough to be mapped are present around many of the major operations, such as sand and gravel pits, limestone and dolomite quarries, and clay and shale pits. The major areas of coal strip mines in Illinois are shown in reports by Reinertsen (1964); Searight and Smith (1969); Smith (1957, 1958, 1961, 1968); Smith and Berggren (1963); and others.

The fills and the waste piles of underground mines and industrial operations include a great variety of materials, but in general they differ from strip-mine waste piles in that the material of the fill is transported and therefore generally differs notably from the material on which it is deposited. Waste piles of underground coal mines near Granville, Putnam County, are typical.

In some fills, such as road and construction fills, the distance of transportation is no greater than that in strip mines, but even in these cases the material of the fills commonly differs from the underlying materials. The sanitary and rubbish fills occupy expanding areas near all cities, towns, and villages, and require separate mapping. They also consist of materials differing greatly from the underlying rocks and pose special environmental problems (Bergstrom et al., 1968; Hackett, 1966, 1968b; Hughes, 1967; Larsen and Hackett, 1965; White and Bremser, 1966; and White and Kyriazis, 1968). Many fills of these types are described in engineering reports.

Some of the waste piles have proved to be valuable mineral resources and have been consumed. Waste piles from underground coal mines in northern Illinois have been used in the manufacture of portland cement, brick, and tile, and in road construction.

SOIL STRATIGRAPHY

Soils, as units of the stratigraphic sequence buried beneath younger sediments, have been recognized in the glacial Pleistocene since the last century. However, it has been only during the past two decades that they have been formally recognized as a separate category of stratigraphic classification (Richmond and Frye, 1957; Willman, Swann, and Frye, 1958; A.C.S.N., 1961). A soil as a unit of stratigraphic classification differs markedly from rock-stratigraphic and time-stratigraphic units because a soil is an entity not susceptible to subdivision or grouping into larger units. Even though one soil may be many times thicker or more strongly developed than another, as a stratigraphic unit each soil must stand alone and cannot be a part of a hierarchy.

A full succession of rock-stratigraphic units exists without the recognition of soil units, and the modification of the sediment

by weathering does not remove it from its rock-stratigraphic unit. Although zonal soils are the product of alteration of sediments downward from a surface at essential equilibrium, some intrazonal soils (accretion-gley and organic soils) are the product of slow accumulation upon an essentially stable subaerial surface. In either type, it is the top of the soil profile that is sharply defined. The top of each soil profile is an unconformity of long or short duration, because surface equilibrium must have existed for a period of time for the soil to have formed. It is this contact that has stratigraphic significance—the soil profile below the plane of contact serves to identify the unconformity and is a paleoecological indicator of the lapsed time.

The soil-stratigraphic unit is placed in sequence, correlated, and named on the basis of the stratigraphic position of its top, but it may be traced into situations where the identifying beds are absent. The characteristic features of a soil may extend downward many feet, or even tens of feet, and its base is gradational. In practice the soil-stratigraphic name in zonal soils extends downward through the A-zone, B-zone, and CL-zone (the zone leached of carbonate minerals) (Frye, Willman, and Glass, 1960; Willman, Glass, and Frye, 1966), but does not include the highly irregular zone of oxidation and chlorite alteration that may extend many feet lower. In intrazonal soils, the soil-stratigraphic name is applied to the deposits that slowly accumulated under soil-forming conditions and to the underlying material that is leached of its carbonate minerals.

Soil-stratigraphic units may overlap many rock-stratigraphic units of different ages. For example, a soil developed largely in shale of Pennsylvanian age (e.g., Lone Oak Section, table 7) is the Sangamon Soil because the Roxana Silt rests on its top. Elsewhere, the Sangamon Soil may be developed in the Pleistocene Banner Formation, any of the several members of the Glasford Formation, the Loveland Silt, the Teneriffe Silt, or the Pearl Formation.

Although a strongly developed soil (Ogallala Climax Soil, Frye and Leonard, 1959) has been observed at many places in the Great Plains below deposits of Nebraskan age, in Illinois a soil at this stratigraphic position has been observed only in Jo Daviess County (Willman and Frye, 1969) and it is not formally named. The soil observed in Tertiary gravels in Illinois is commonly overlain by silts of Illinoian age and is called the Yarmouth Soil, even though its development may have started during the Pliocene.

Afton Soil

The Afton Soil is the lowest named soil-stratigraphic unit in the Pleistocene of Illinois (fig. 1). The name is derived from the Aftonian Stage, which was first described by Chamberlin in 1895 from exposures in a gravel pit near Afton Junction, Union County, Iowa. The gravels at that locality are between two tills, subsequently correlated with the Kansan and Nebraskan, but no well developed zonal soil occurs between them.

The Afton Soil as a formal soil-stratigraphic unit was introduced by Frye and Leonard in 1952 and described from a typical exposure in the Iowa Point geologic section in Doniphan County, Kansas. The name Afton was retained because of the long-established use of Aftonian for the interglacial stage, in spite of the absence of the soil at the original type locality and considerable uncertainty concerning the age of the till in Union County, Iowa (Kay and Apfel, 1929, p. 191). In Illinois the Afton Soil is based on a strongly developed soil (Zion Church Section, table 6) in a stratigraphic position below till correlated with the Kansan till of Iowa and Kansas (Willman, Glass, and Frye, 1963; Frye, Willman, and Glass, 1964), and it is developed in deposits correlated with the Nebraskan Stage. The Afton Soil has been observed at only a few outcrops in Illinois and in a few borings in west-central Illinois. It has considerable stratigraphic significance, permitting the correlation of this early Pleistocene datum westward across Iowa and the Great Plains.

No Afton Soil accretion-gleys have been observed in Illinois. Deposits of organic

silt below till of Kansan age at the Mill Creek Section in Adams County (table 7) may represent an accreted Afton Soil. If so, the soil lacks the distinctive character and high clay content of the accretion-gleys of the younger soils. At the Zion Church Section, the Afton is a deep in-situ soil profile developed in outwash of Nebraskan age. Its B-zone is red-brown to red, strongly impregnated with heterogeneous swelling clay minerals that are indicative of intensive or prolonged weathering to a depth of more than 5 feet below an upper contact that has been truncated to the B_2-zone.

A deeply truncated Afton Soil is exposed in a few sections along the west side of the Illinois River Valley (e.g., Enion Section, table 6; Rushville (2.4 W), table 7), but it is difficult to evaluate the profile characteristics from these exposures.

Yarmouth Soil

The Yarmouth Soil was named and described by Leverett in 1898 from its occurrence in a well at Yarmouth in Des Moines County, Iowa. Leverett proposed Yarmouth as a replacement for the older term Buchanan, and his new type locality demonstrated occurrence of the soil below deposits of Illinoian age. He described the soil as the weathered zone on the Kansan drift. The Yarmouth Soil occurs both as an accretion-gley and as an in-situ profile developed in older deposits.

Yarmouth Soil is described in six of the geologic sections in this report (table 6). In the Cache and Gale Sections it is an in-situ soil developed in Mounds Gravel and overlain by Loveland Silt. In both of these localities the period of soil formation may have been much longer than the Yarmouthian Stage, and the soil was truncated before deposition of the overlying Loveland Silt. At the Enion Section the Yarmouth Soil is developed in sand and gravel of the Banner Formation, and at the Tindall School Section it is developed in till of the same formation. At both localities it is a deeply developed in-situ profile that had been somewhat truncated prior to the deposition of the overlying Glasford Formation. At the Petersburg Dam and Zion Church Sections it is an accretion-gley assigned to the Lierle Clay Member of the Banner Formation.

The mineral composition and sequence of mineral alteration has been described for Yarmouth Soil in the Fort Madison, Iowa, area (Willman, Glass, and Frye, 1966), at the Rushville (4.5 W) Section, Schuyler County, Illinois (Willman, Glass, and Frye, 1963), where the soil occurs on till of Kansan age and is overlain by till of Illinoian age, and at the Dixon Creek Sections in Jo Daviess County (Willman and Frye, 1969), where the soil is developed in dolomite gravel and in dolomite of the Galena Group (Ordovician) that is overlain by Loveland Silt. The soil has been described in the Independence School Section (table 7), at several localities in Fulton and Peoria Counties by Wanless (1957), and in Christian, Menard, and Sangamon Counties by Johnson (1964).

The Yarmouth Soil occurs as three distinctly different types of profiles. The accretion-gley profiles consist of slowly deposited clay, silt, and some sand that accumulated in poorly drained or undrained areas on the till plain. The sediment was moved to the low spots by sheetwash and deposited in an intermittently wet, reducing environment. These deposits (formerly called "gumbotil") possess a distinctive mineralogy (Frye, Willman, and Glass, 1960; Willman, Glass, and Frye, 1966) characterized by a very high percentage of expandable clay minerals, a gray to gray-black color, and a massive and highly plastic character when wet. The accretion-gley deposit overlies the till with a sharp contact, and the contact at the top with overlying Petersburg Silt, till of the Glasford Formation, or Loveland Silt, is equally sharp. At some localities the uppermost part of the accretion-gley was secondarily oxidized before burial by sediments of Illinoian age. Because of its distinctive lithology and generally sharp contacts, the accretion-gley is differentiated in rock-stratigraphy as the Lierle Clay Member of the Banner Formation.

The second type of Yarmouth Soil contains the zonal profiles that developed in sediments of Kansan age under conditions of moderate to good surface drainage. These profiles are more or less oxidized and mineral alteration decreases downward. The solums are characterized by clay of a heterogeneous swelling type. They have typically gray-brown to red-brown B-zones and contain pellets and platelets of Mn-Fe, clay skins, and strongly developed peds (soil structure). The maximum depth of profile development is more than 20 feet.

The third type of Yarmouth Soil contains a wide range of profiles developed in sediments older than Kansan that extend to dolomites of Ordovician age. Most striking in this type is the residual geest developed on dolomite that displays clay pendants extending downward into the widened joints of the bedrock to depths of 6 to 8 feet below the top of the soil (e.g., Christian Hollow Church Section, table 7). Such soils are overlain with sharp contact by tills and silts of Illinoian age, are predominantly massive clay of strongly degraded clay mineral types, and are red-brown to mahogany in color. Yarmouth Soils of this class have been observed in southern Illinois developed in shales of Pennsylvanian age (e.g., Marion Northwest Section, table 7). Also in this class are soils developed in colluvium (e.g., Seehorn Section, table 7).

Yarmouth Soils of all classes are sharply bounded at the top by overlying deposits of the Loveland, Petersburg, Glasford, or Pearl Formations.

Pike Soil (New)

The Pike Soil is named here for Pike County from its occurrence in the New Salem Northeast Section (table 6), NW NE SW Sec. 11, T. 4 S., R. 4 W. At its type locality the Pike Soil is developed in the Kellerville Till Member of the Glasford Formation (Liman Substage, Illinoian Stage). It is overlain by the Teneriffe Silt (Monican and Jubileean Substages, Illinoian Stage), which contains the Sangamon Soil in its top and is overlain by Roxana Silt and Peoria Loess (fig. 7). The Pike Soil presents a strongly developed, clayey, red-brown profile, lacking strongly developed peds, or structure, and Mn-Fe pellets. At the relatively few localities where this soil has been studied in western Illinois, it is commonly truncated and is overlain by the Duncan Mills Member or Hulick Till Member of the Glasford Formation or by the Teneriffe Silt.

In the stratigraphic sections included in this report (table 6), the Pike Soil has been described in the Cottonwood School, Enion, New Salem Northeast, and Pleasant Grove School Sections. Mineralogical studies have been made at each of these sections. Although this soil has been observed at several other localities it seems clear that it does not occur widely—or if it does, it has been miscorrelated. The scarcity of exposures seems to be accounted for by widespread erosion before the deposition of the Hulick Till Member of the Glasford Formation. It nevertheless has considerable stratigraphic significance because it establishes the existence of a sizable unconformity after the deposition of the Kellerville Till and prior to the deposition of the Hulick Till. The significance of this hiatus is also shown by the contrast in topography between the areas where the Kellerville and Hulick are surface tills and by the greater depth of leaching of the Kellerville Till.

A very weakly developed soil, as yet unnamed, has been observed in the Jubilee College Section (table 6), and in a few other places below the Radnor Till Member of the Glasford Formation (fig. 7). At those places where the Duncan Mills, Hulick, and Toulon Members of the Glasford Formation were not deposited, the soil-forming interval of the Pike Soil continued until it was terminated by the advancing Radnor glacier or by deposition of the contemporaneous part of the Teneriffe Silt. Furthermore, at some places it is probable that after the deposition of the Kellerville Till the soil-forming interval continued uninterrupted until terminated by deposition of Roxana Silt. Such a soil is the Sangamon and not the Pike Soil.

Sangamon Soil

The Sangamon Soil was named by Leverett (1898b) on the basis of a description of a soil in a well in Sangamon County given by Worthen (1873b). Leverett described the soil as occurring below deposits of Wisconsinan age and typically developed in the northwestern part of Sangamon County and the neighboring parts of Menard County. The original section described by Worthen was not examined by Leverett or by subsequent workers, and it seems appropriate, therefore, to designate several reference sections that are available for examination in the region surrounding the type locality. Two described stratigraphic sections included with this report may be regarded as paratypes.

The Chapin Section (table 6), NW SE NE Sec. 8, T. 15 N., R. 11 W., Morgan County (adjacent to Sangamon County on the west), serves as a representative and easily accessible reference section. The Sangamon Soil here is an in-situ profile developed in till of the Hulick Till Member of the Glasford Formation. It is overlain by the Markham Silt Member of the Roxana Silt, and thus the top of the profile is at the defined position for the Sangamon Soil. However, as the profile is developed in the Hulick Member, with the Radnor Till Member and Toulon Member of the Glasford Formation missing, the interval of soil formation was longer than the Sangamonian Stage, and the profile is somewhat more strongly developed than it is where the soil is developed in the Radnor Till Member. Carbonate minerals are leached to a depth of 6.5 feet, and the B_2-zone is 2 feet thick, red-brown, and clayey, with Mn-Fe pellets and staining.

The Rochester Section (table 6), NW SE NW Sec. 34, T. 15 N., R. 4 W., eastern Sangamon County (Frye, Willman, and Glass, 1960), serves as a representative section of the Sangamon Soil accretion-gley profile. Here, the accretion-gley deposit, classed as the Berry Clay Member of the Glasford Formation, is typical of the intrazonal soil profile of the Sangamon Soil. It is gray to blue-gray massive clay, with some dispersed small pebbles and sand grains. The accretion-gley has a sharp contact with the till below, and the till is leached of carbonate minerals 2 feet below the contact. The interval of soil formation exceeded the time span of the Sangamonian Stage. The till below is classed as the Vandalia Till Member of the Glasford Formation, and the youngest Illinoian till is absent. Although Roxana Silt overlies the soil up the hill immediately to the north (Frye and Willman, 1963b, p. 23), at the position of the section described, it has been truncated, and Peoria Loess immediately overlies the accretion-gley. A 6-inch, in-situ, oxidized soil developed in the top of the accretion-gley is thought to be the Farmdale Soil.

Other stratigraphic sections in this report (table 6) also describe the Sangamon Soil. In-situ profiles in till are described in the Campbells Hump, Cottonwood School, Farm Creek, Flat Rock, Jubilee College, Pulleys Mill, Tindall School, Toulon, and Washington Grove Sections. In-situ profiles developed in Teneriffe Silt are described in the Enion, New Salem Northeast, Pleasant Grove School, and Washington Grove Sections, and others developed in Loveland Silt are described in the Gale and Zion Church Sections.

Sangamon Soil has been described as an in-situ profile developed not only on Illinoian deposits including tills, Teneriffe Silt, Loveland Silt, and the Pearl Formation, but also on bedrock shale units of Pennsylvanian age (Lone Oak Section, table 7) and dolomites and sandstones as old as Ordovician age (Henze School, Wolf Creek Sections, table 7). Sangamon Soil accretion-gleys have been studied at dozens of localities, and their mineralogy has been examined in detail (Frye, Willman, and Glass, 1960; Willman, Glass, and Frye, 1966).

The Sangamon Soil as an in-situ profile on till is generally more deeply and strongly developed in southern Illinois (e.g., Pulleys Mill, table 6) than it is in central Illinois (Funkhouser and Hipple School Sections, table 7; Jubilee College and Tindall School Sections, table 6) or in north-

ern Illinois (Damascus East, Haldane West, Kewanee North Sections, table 7). The in-situ profiles in till generally display moderately good drainage and are red-brown, but at some places (e.g., Fairview, New City Sections, table 7) the profiles in till are poorly drained and are dark gray to gray-brown. The depth of leaching diminishes somewhat northward, but the change in profile characteristics across the 400-mile north-to-south distance is not as great as would be expected from the present range in climate across this distance.

As an in-situ profile on silt (Loveland and Teneriffe Silts) the Sangamon Soil is deeper, better drained, redder, and more massive (e.g., Pleasant Grove School Section, table 6; Mt. Carroll North, Siloam West Sections, table 7) than in profiles developed on till. The same generalization is true for Sangamon Soil developed on the Pearl Formation (e.g., Lost Prairie, Mt. Carroll South, Pearl Prairie Sections, table 7). Sangamon Soil profiles developed on bedrock (e.g., Lone Oak Section, table 7) are generally relatively thin but intensely developed.

Sangamon Soil accretion-gley (Berry Clay Member), through the years, has been the most widely recognized and described soil type, and it formerly was referred to as "gumbotil." Accretion-gley occurs on the Sterling Till Member (Coleta, Red Birch School Sections, table 7), the Ogle Till Member (Lanark East Core Section, Frye et al., 1969), the Hulick Till Member (Fairview, Hipple School Sections, table 7), the Vandalia Till Member (Effingham, Funkhouser East, Jewett, Panama-A, Ramsey Creek Sections, table 7), and the Kellerville Till Member (Rapids City (B) Section, table 7) of the Glasford Formation. Even though these tills range from early to late Illinoian in age and the localities range geographically through two thirds of the dimensions of the state, no significant differences have been detected in the character of the accretion-gley. Detailed mineralogical studies have been reported for the accretion-gley at the Effingham, Fairview, Hipple School, and other sections (Frye, Willman, and Glass, 1960; Willman, Glass, and Frye, 1966). In contrast to the in-situ Sangamon Soil, the accretion-gley profiles are not sharply defined at the top. This appears to be the result of the persistence of the poor drainage and gleying conditions after the end of Sangamonian time, with the resultant incorporation of the slowly deposited early Wisconsinan sediments into the gleyed material (Bunker Hill Section, Macoupin County, table 7). At a few places (e.g., Panama-A Section, table 7) stratigraphic differentiation can be observed within the accretion-gley deposit. Also, in some exposures (e.g., Hipple School Section, table 7) the margin of the lens of accretion-gley shows the shallow topographic depressions in which the material accumulated and the continuity with the in-situ Sangamon Soil developed on till at slightly higher positions.

Chapin Soil (New)

The Chapin Soil is herein named for Chapin, Morgan County, from its occurrence in the Chapin Section (table 6), NW SE NE Sec. 8, T. 15 N., R. 11 W. It is an in-situ profile developed in silt and colluvium overlying the Sangamon Soil, and the mineralogy has been described in the Chapin and Cottonwood School Sections (table 6) and in the Browns Mound, Hillview, Hipple School, Literberry, Reliance Whiting Quarry, Varna (table 7), and other sections. The Chapin Soil is the first soil above the Sangamon Soil and is developed in the thin Markham Silt Member of the Roxana Silt. Along the Illinois (Ancient Mississippi) Valley, the Markham Member contains some contemporaneous loess, which makes the Chapin Soil distinguishable mineralogically as well as morphologically from the underlying Sangamon Soil. However, along the Mississippi Valley of west-central Illinois (as well as in eastern Iowa where it has been called "upper story Sangamon"), the Markham Member is composed largely of colluvium derived from the surface of the Sangamon Soil and there is no mineralogical differentiation (only morphologic and

color differences) between the Chapin and the Sangamon Soil below.

Although the Markham Silt Member is commonly less than 1.5 feet thick, the Chapin Soil is strongly developed, and in some places the B_2-zone rests on the A-zone or truncated B_2-zone of the Sangamon Soil below. It generally is distinctly less red than the underlying Sangamon Soil, but at no locality has a calcareous zone been observed between the Chapin Soil and the Sangamon Soil. At most localities the B_2-zone of the Chapin rests upon the Sangamon Soil.

Even though the rock-stratigraphic unit in which the Chapin Soil is developed is quite thin, this soil has stratigraphic significance because it furnishes the only datum for correlation within the early part of the Altonian Substage. It is also the most strongly developed soil within the Wisconsinan Stage, and it serves as an important paleoecological indicator for early Altonian time.

Pleasant Grove Soil (New)

The Pleasant Grove Soil is herein named for Pleasant Grove School, from its occurrence in the Pleasant Grove School Section (table 6), center SE Sec. 20, T. 3 N., R. 8 W., Madison County. At its type locality the Pleasant Grove Soil is developed in the McDonough Loess Member and overlain by the Meadow Loess Member of the Roxana Silt. The soil at the type section presents an "A-C" profile, lacking a recognizable B-zone. A dark gray, organic-rich A-zone occurs above tan to gray-tan leached loess, and 2 to 3 feet below the top of the soil the loess is weakly calcareous and contains a few badly etched fossil polygyrid shells. A few "pods" of seed hulls of *Celtis occidentalis* occur 1.5 to 2.5 feet below the surface of the buried soil, suggesting the action of burrowing rodents that lived on the soil surface.

The contrast in degree of development between the Pleasant Grove and Chapin Soils is as great as that between the Chapin and Sangamon Soils. These contrasts in morphology suggest that, whereas the Chapin Soil required only a fraction of the time that was needed for the development of the Sangamon Soil, the Pleasant Grove Soil required only a fraction of the time required for the development of the Chapin Soil. At the type section a radiocarbon date of 35,200 ± 1,000 (W-729) was obtained on shells from the middle of the Meadow Loess Member above the Pleasant Grove Soil, and other radiocarbon dates as old as 37,000 B.P. have been obtained from the mid-part of the Meadow Member.

Farmdale Soil (New)

The Farmdale Soil has not previously been described formally as a soil-stratigraphic unit though the peaty deposits of the Farmdale Silt (now the Robein Silt) and the Farmdalian Substage were described many years ago. It is named for Farmdale, Tazewell County. Its type section is the Farm Creek Section (table 6), NE SW SE Sec. 30, T. 26 N., R. 3 W., Tazewell County, which was the type section for the Farmdale Loess and Farmdale Silt and also serves as the type section for the Robein Silt and the Farmdalian Substage.

Among the soil-stratigraphic units in the Pleistocene deposits of Illinois, the Farmdale Soil is unique. At its type section it is an intrazonal, organic-rich soil, formed by the accumulation of organic debris and silt from sheetwash and eolian deposition. It resembles the accretion-gley soils in that it is developed by the slow accretion of material in a poorly drained locality, but it differs from them in that it is a deposit composed largely of silt and organic debris rather than of clay and it quite clearly accumulated at a more rapid rate than did the accretion-gleys. The Farmdale Soil is also unique in that it has yielded more than 20 radiocarbon dates (table 1), ranging from approximately 21,000 B.P. to approximately 27,000 B.P., from localities in Illinois.

The accreted organic-rich Farmdale Soil generally rests on Roxana Silt and is over-

lain by Morton Loess, Peoria Loess, or the Wedron Formation (fig. 8). It has been observed widely in central and northern Illinois (e.g., Campbells Hump and Tindall School Sections, table 6; Danvers, Enion Terrace, McAllister School, Perry Northeast, Richland Creek, Secor, and Union School Sections, table 7).

In-situ profiles of the Farmdale Soil, where they occur in relatively thick loess sections and, particularly, close to the valleys of the Mississippi and Illinois Rivers, are nearly everywhere truncated into or below the B_2-zone of the soil. The episode of widespread erosion that coincided with the advance of the Woodfordian glaciers was particularly effective in the areas of sharp topographic relief adjacent to major valleys, whereas the poorly drained, and thus protected, situations where the accreted Farmdale Soil had accumulated were relatively little affected. Therefore, the Farmdale Soil in thick loess sections commonly consists of a deeply leached CL-zone, as much as 10 feet or more deep, overlain at an erosional contact by calcareous Peoria or Morton Loess (e.g., Cottonwood School, Gale, Jubilee College, Pleasant Grove, Pulleys Mill, and Zion Church Sections, table 6).

A fully developed in-situ Farmdale Soil can be observed only in the areas of relatively thin loess on relatively flat uplands remote from major drainage (e.g., Henze School, New City, Rushville (4.5 W), Schuline Sections, table 7). In such places the profile generally displays a reddish brown, clayey B_2-zone that grades downward to a B_3-zone and a CL-zone; it is generally unstructured, and the A-zone at the top grades upward into the base of the overlying Peoria Loess.

The Farmdale Soil is exceeded only by the Sangamon Soil in its use as a widespread stratigraphic datum within the Pleistocene deposits of Illinois.

Jules Soil (New)

The Jules Soil is named for Jules, Cass County, from its occurrence in the Jules Section (Frye, Glass, and Willman, 1968). Its occurrence has also been described in the Cottonwood School (table 6) and Frederick South (table 7) Sections. The Jules is the most weakly developed of the formally named soil-stratigraphic units in Illinois. It commonly is an "A-C" profile and lacks a textural, or structured, B-zone. Furthermore, at some places it splits into two or even three A-zones separated by as much as 1 to 1.5 feet of somewhat weathered loess. It has been observed only in the thick loess sections adjacent to the Illinois River Valley. It occurs only within the Peoria Loess.

It merits recognition as a named buried soil because it can be readily observed in the field, and mineralogical studies (Frye, Glass, and Willman, 1968) have shown that it marks the boundary between two zones in the Peoria Loess. These two zones cannot be distinguished in the absence of the Jules Soil. However, they show that the Jules Soil correlates with the boundary between the Tiskilwa and Malden Till Members of the Wedron Formation.

Two Creeks Soil

The Two Creeks Soil, although not formally defined as a soil-stratigraphic unit, has been used in this sense in recent years (Frye, Willman, and Black, 1965). The soil, as well as the Twocreekan Substage, is based on the exposures in the bluffs adjacent to Lake Michigan 2 miles east of Two Creeks, Manitowoc County, Wisconsin (Secs. 11 and 12, T. 21 N., R. 25 E.). At the type locality the soil is intrazonal and consists of an accumulation of organic material and silt above somewhat weathered silt. Data from the wood found in the soil indicate that the soil supported forest growth for at least 150 years (Wilson, 1936). The organic material has been extensively radiocarbon dated (Black and Rubin, 1968).

In Illinois, an in-situ Two Creeks Soil profile has not been identified with certainty. However, in alluvial deposits of both major and minor valleys, several soils with weakly developed profiles have been observed in positions that suggest an age

equivalent to, or younger than, the Two Creeks Soil. The Two Creeks Soil is not now a useful stratigraphic unit in Illinois, but because of its significant occurrence in adjacent southeastern Wisconsin it should be recognized. Still younger soils that occur buried in the alluvial and lacustrine deposits of Illinois are not formally named or described pending future detailed studies.

Modern Soil

The term Modern Soil is applied to any soil profile genetically related to the modern topographic surface. The soil ranges from very shallow to many feet in depth and is developed in any sediment that may underlie the present surface. In a stratigraphic sequence it is overlain only by man-made deposits.

The Modern Soil is the soil described in the many county soil reports of the University of Illinois Agricultural Experiment Station and of the U. S. Department of Agriculture Soil Conservation Service. As a stratigraphic entity the type section is designated units 4-8 of the Buda East Section (Frye, Glass, and Willman, 1968, p. 20), SE SE SW Sec. 31, T. 16 N., R. 8 E., Bureau County. This unit has long been called "Modern Soil," and it seems undesirable to replace it with a geographic name.

MORPHOSTRATIGRAPHY

The only formal morphostratigraphic units recognized in Illinois are the units related to the moraines that are called "drifts." The moraines of Woodfordian age form the basis for a nearly complete sequence of units. The moraines in the Altonian and Illinoian drifts are discontinuous and only in local areas serve as a useful basis of reference. The alluvial terraces, which occur along many valleys, are also classified as morphostratigraphic units. However, most of the terraces have been differentiated and named in such local segments of the valleys that, pending more detailed correlation, they are considered as informal stratigraphic units. Those named are listed at the end of this section.

The Woodfordian glaciers that invaded Illinois came from two major lobes, the Erie Lobe and the Lake Michigan Lobe (fig. 12). The former may include ice from the Saginaw Lobe, and the latter may include ice from the Green Bay Lobe. The Erie Lobe has only one sublobe in Illinois, the Decatur Sublobe. The Lake Michigan Lobe, in response to the topography, at its maximum advance divided into three sublobes, the Peoria, Green River, and Dixon Sublobes. On later readvances the lobes took different shapes and are classified into three additional sublobes, the Princeton, Harvard, and Joliet Sublobes.

The Woodfordian glacial deposits, which cover a third of Illinois, consist of a sequence of till sheets that terminate in moraines, are superimposed in a shingle-like pattern, and are commonly separated by waterlaid deposits. The named drifts include the outwash related to the moraine. The drifts record the pulsing movement of the ice front during the progressive withdrawal from the position of maximum Woodfordian glaciation. The sequence in areas far back from the Woodfordian front is seldom complete and in many places is difficult to correlate because (a) the distance the ice front readvanced before building some moraines was probably small, or even negligible; (b) the drifts are not everywhere separated by waterlaid deposits; (c) the drifts of several successive moraines do not differ notably in composition; (d) some moraines are overridden by later readvances; and (e) glacial erosion removed segments of the record. Nevertheless, the relation of the drift sheets to the sequence of moraines can be worked out in detail in some areas, and in most areas of the Woodfordian glacial de-

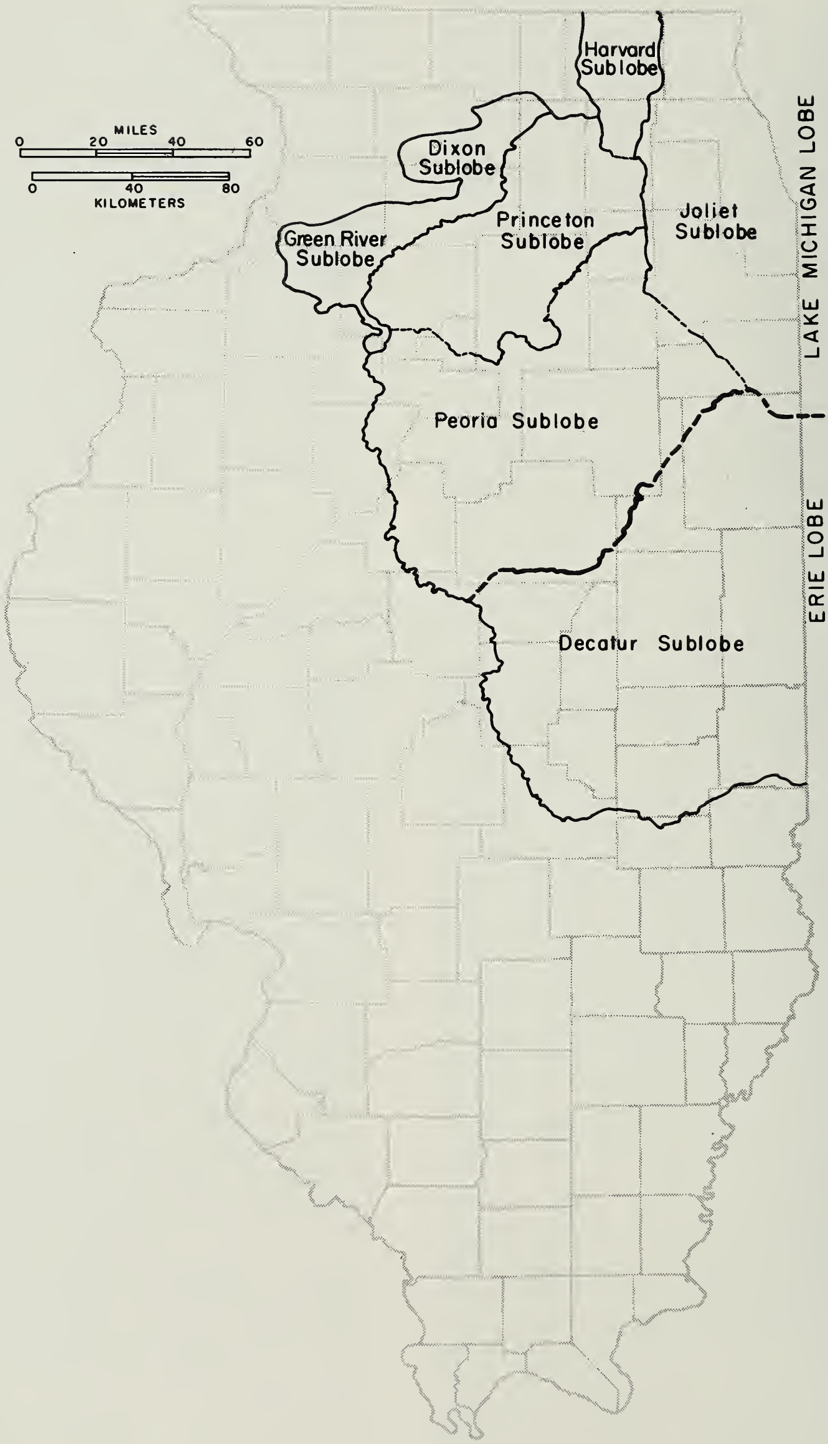


Fig. 12 — Woodfordian lobes and sublobes in Illinois.

posits it provides a basis of stratigraphic differentiation that permits a finer subdivision than can be attained by other schemes of stratigraphic classification.

Units of drift distinguished by field characteristics such as color, grain size of the matrix, or abundance of pebbles, cobbles, and boulders, are classified as rock-stratigraphic units. Variations in the relative abundance of the clay minerals, heavy minerals, and carbonate minerals are helpful in correlating some of the drifts.

In revising the previous mapping and nomenclature of the Woodfordian moraines (pl. 1), we have not projected names across large gaps in continuity, particularly where alternative correlations are possible. The tracing of crests as well as fronts has made it possible to subdivide several morainic areas not previously differentiated, and improved topographic maps have permitted recognition of some moraines not previously mapped. Although many of the moraines can be subdivided further, small ridges not mappable on the 1:500,000 scale are not named.

The drifts are described by lobes and sublobes. No type sections are required, but the area for which the moraine is named is considered the type locality.

Erie Lobe

Decatur Sublobe Drifts

The Woodfordian Erie Lobe is represented in Illinois only by the Decatur Sublobe (fig. 12), which is named for Decatur, Macon County, located on the outermost moraine of the lobe. It includes two morainic systems and 22 named moraines (pl. 1). Although all may represent different times of moraine building, overlaps and discontinuities locally obscure the original continuity, and several of the moraines may be contemporaneous. However, the relations between the moraines require a minimum of 17 episodes of moraine building.

None of the 18 moraines older than the Chatsworth (pl. 1) can be directly correlated to specific moraines in the bordering Peoria Sublobe of the Lake Michigan Lobe. The Chatsworth appears to be continuous into both lobes, which suggests that until Chatsworth time the pulses of the two lobes were not entirely synchronous. Although the Illiana Morainic System in the Decatur Sublobe is approximately contemporaneous with the Bloomington Morainic System in the Peoria Sublobe, the truncating relations at their contact in the Gibson City reentrant suggest that the Illiana Moraines are somewhat younger.

Shelbyville Drifts

Shelbyville Drifts include all drift related to the Shelbyville Morainic System (pl. 1). It is the outer and oldest drift in both the Decatur and Peoria Sublobes. The Shelbyville Morainic System was named by Leverett in 1897 for Shelbyville, Shelby County. He described the drift in more detail in 1899 and classified it as Substage 1 of the Early Wisconsin. In eastern Illinois it consists of three well defined moraines—Westfield, Nevins, and Paris. A fourth weakly morainic ridge extends southwest from Kansas, Edgar County, for a few miles but is not differentiated from the Paris. Each of the three moraines locally has more than one well defined crest. Farther west and north the Shelbyville Moraines are not separable, although parallel crests can be recognized in some places. The prominence of the moraine northward from Shelbyville to Peoria probably results from superposition of the three moraines. In that area numerous small lobate areas along the front may represent temporary projections of one of the ice sheets. However, some of these have a symmetrical surface and may represent mudflows or till slumps down the steep frontal slope of the moraine (Hester and DuMontelle, in press).

In the Decatur Sublobe, the volume of drift in the Shelbyville Morainic System varies greatly along the east-west trend from the Illinois-Indiana state line to Shelbyville. At the state line the moraine is a single unit less than 2 miles wide, and it rises only 30 to 40 feet above the Illi-

noian till plain. Just 6 miles west it broadens to 6 miles wide, rises 100 to 150 feet, and separates into the three moraines. It has a maximum width of 10 miles near Charleston, but westward it again narrows and 25 miles west, at Shelbyville, it is only about a mile wide and 50 feet high. This represents a decrease in volume of the drift in the moraine in the order of 20 times.

The Shelbyville Drifts are dominantly slightly sandy gray till that in places have a slightly pink cast. They form the surface drift back to the next younger moraine, which is the Champaign, Cerro Gordo, Arcola, or West Ridge Moraine. Farther north and east they underlie, and are generally separable from, the younger drifts (Eklaw and Willman, 1955) and continue in some areas beneath the pink till of the Illiana Morainic System. Where only one drift is present beneath the Champaign, Urbana, or Illiana Drifts, it is referred to the Shelbyville Drift.

Westfield Drift (New)

The Westfield Drift, named for Westfield, Clark County, is based on the Westfield Moraine (pl. 1), which is the outer of the three moraines in the Shelbyville Morainic System. The moraine is 1 to 2 miles wide, 40 miles long, and its crest is about 100 feet above the Illinoian till plain.

Nevins Drift (New)

The Nevins Drift, named for Nevins, Edgar County, is based on the Nevins Moraine (pl. 1), which is the middle of the three moraines of the Shelbyville System. The moraine is differentiated through about the same area as the Westfield Moraine and is approximately the same width and height. It is separated from the adjacent moraines by a narrow, discontinuous, frontal valley and, where the valley is absent, is extended by tracing its crest.

Paris Drift (New)

The Paris Drift, named for Paris, Edgar County, is based on the Paris Moraine (pl. 1), which is the inner moraine of the Shelbyville Morainic System. The Paris is broader, as much as 4 miles wide, and has a more irregular crest, generally about 50 feet lower, than the Westfield and Nevins Moraines. In its western part it is separated from the Nevins Moraine by well defined valleys, tributaries of the Embarras River. It is the most extensive of the three Shelbyville Moraines, extending westward beyond the area where the Westfield and Nevins Moraines can be differentiated. At its eastern end it abruptly narrows, its morainic topography diminishes within a few miles, and it terminates before reaching the Indiana state line.

Heyworth Drift (New)

The Heyworth Drift is named for Heyworth, McLean County, and is based on the Heyworth Moraine (pl. 1), a weakly morainic area with a maximum width of about 4 miles that extends southward from Heyworth to near Clinton, De Witt County. The morainic topography has only slightly greater relief and roughness than the adjacent groundmoraine. However, it has a distinct front, and the crest is 40 to 50 feet higher than the surface west of the moraine. A morainic ridge trending northeast-southwest, a mile southeast of Clinton, is included in the moraine. The orientation and lack of continuity of both segments suggest the possibility that they are related to features buried by Shelbyville Drift.

Turpin Drift (New)

The Turpin Drift is named for the village of Turpin, 3 miles southeast of Decatur, Macon County. It is based on the Turpin Moraine (pl. 1), a sharp morainic ridge about 6 miles long and 1 to 2 miles wide, with a relief of 25 to 50 feet, that extends northeast from Turpin to the front of the Cerro Gordo Moraine. The ridge may mark a temporary stand of the ice front during retreat from the Shelbyville Moraine. However, its orientation normal to the Shelbyville and Cerro Gordo Moraines suggests that it may be a ridge on the Illinoian till plain mantled by Shelbyville Drift, and, if

further study indicates that this is the case, the term Turpin Drift will not be needed.

Cerro Gordo Drift

The Cerro Gordo Drift, named for Cerro Gordo, Piatt County, is based on the Cerro Gordo Moraine (Leverett, 1899a) (pl. 1). The moraine is a strongly lobate ridge about 80 miles long and generally 2 to 3 miles wide. It is truncated on the north by the Champaign Moraine and on the south by the Arcola Moraine. It previously had been continued about 25 miles farther east, but that segment is a continuation of the Arcola Moraine. Along its northwestern limb, the crest of the moraine is commonly 50 to 60 feet above the till plain in front, and a few hills are as much as 100 feet high. The southeastern limb is not as strong as the northwestern, but it is well defined, and its crest is 20 to 40 feet high. In its most advanced part, the moraine is weak and discontinuous, unlike most moraines in which the most advanced parts contain the bulk of the drift. Apparently the Cerro Gordo glacier started to retreat immediately after reaching its maximum advance.

The Cerro Gordo Moraine has been assumed to represent a significant readvance because of its different orientation and because a thin leached zone on gravel, which is correlated with the retreatal Shelbyville, is overlain by Cerro Gordo till (Ekblaw and Willman, 1955). However, the age of the gravel and till is not definite. In the Peoria Sublobe, the Le Roy Moraine forms a similar strongly lobate moraine inside the Shelbyville Moraine, and its correlation with the Cerro Gordo has been suggested. Both are truncated by the Champaign Moraine, but their exact relation is not clear.

Arcola Drift

The Arcola Drift, named for Arcola, Douglas County, is based on the Arcola Moraine (Leighton and Brophy, 1961) (pl. 1). The moraine is about 50 miles long and forms two well defined lobes. The western lobe is largely a broad, flat-topped ridge, 3 to 4 miles wide and only 20 to 30 feet high, but the eastern limb is half as wide and twice as high. The moraine is truncated at the north, south of Tolono, by the Pesotum Moraine. In Douglas County the western lobe enclosed a large lake (Ekblaw, *in* Flint et al., 1959), called Lake Douglas, in which as much as 20 feet of laminated clays and silts accumulated (Gardiner, Odell, and Hallbick, 1966). The outlet of the lake along the Embarras River, 3 miles northwest of Oakland, is a narrow channel about 90 feet deep. The moraine forming the eastern lobe, previously considered part of the Cerro Gordo Moraine, is narrower and less prominent, and it abruptly diminishes in size and ends north of Paris.

Pesotum Drift

The Pesotum Drift, named for Pesotum, Champaign County, is based on the Pesotum Moraine (Leighton and Brophy, 1961) (pl. 1). The moraine is traceable for only about 25 miles. It is truncated at the north end by the Champaign Moraine and at the south end by the West Ridge Moraine. It is a flat-topped ridge 1 to 2 miles wide, rising 25 to 50 feet above the surface in front of the moraine. It previously was considered part of the West Ridge Moraine, from which it is separated by a well defined valley south of Pesotum, but from there north to Champaign the separation is only a slight sag.

West Ridge Drift

The West Ridge Drift, named for West Ridge, a small village 3 miles southwest of Villa Grove, Douglas County, is based on the West Ridge Moraine (Leverett, 1899a) (pl. 1). Leverett considered this the outer moraine of his Champaign Morainic System. It is truncated by the Champaign Moraine on the north but extends eastward for about 50 miles until overlapped by the Hildreth Moraine. Like both the Arcola and Pesotum Moraines, it has a north-south segment that forms a broad flat-topped ridge 2 to 3 miles wide and rises only 25 feet above the stream along its front. However, the east-west segment is a prom-

inent ridge, most of which is 1 to 2 miles wide and 50 to 75 feet high.

Hildreth Drift (New)

The Hildreth Drift, named for the village of Hildreth, Edgar County, 5 miles south of Sidell, is based on the Hildreth Moraine (pl. 1). The Moraine is a weak ridge, only 20 to 25 feet high, and extends eastward from its contact with the Champaign Moraine south of Urbana for about 25 miles. From that point for about 25 miles farther eastward to the Indiana state line, it is a narrow but distinct ridge generally 40 to 50 feet high. It becomes much weaker again near the state line. It has previously been undifferentiated or included in the Champaign Moraine. It is much smaller than the massive Champaign Moraine, and its relation to that moraine is masked by the overlapping Urbana Moraine.

Ridge Farm Drift (New)

The Ridge Farm Drift, named for Ridge Farm, Vermilion County, is based on the Ridge Farm Moraine (pl. 1) and was previously called the Middle Champaign Moraine in the Danville region (Eveland, 1952). It is a well defined ridge extending about 25 miles from its contact with the Urbana Moraine to the Illinois-Indiana state line. It is 1 to 2 miles wide and its crest has a maximum height of 30 to 40 feet above the valley along its front. Several isolated patches of morainic topography behind the moraine may represent a temporary stand during retreat of the ice but are included in the Ridge Farm Moraine. Although the Ridge Farm and Hildreth Drifts may be a continuation of the Champaign Drift east of the area where it is overlapped by the Urbana Moraine, evidence of continuity is lacking and separate names seem preferable.

Champaign Drift

The Champaign Drift, named for Champaign, Champaign County, is based on the Champaign Moraine (pl. 1), which was named the Champaign Morainic System by Leverett (1897). He interpreted the Champaign Morainic System as Substage 2 of the Early Wisconsin drift sheets. Leverett subdivided the morainic system into outer, middle, and inner ridges, which approximately correspond to the West Ridge–Pesotum, Hildreth–Ridge Farm, and Urbana Moraines. Because of the complex overlapping relations of these moraines in Urbana, the name Champaign is restricted here to the main moraine extending northwest from Champaign for 30 miles to its termination at Saybrook, McLean County, where it is truncated by the Bloomington Moraine of the Peoria Sublobe. At the contact of the sublobes, the gray clayey till of the Champaign Drift is readily distinguished from the yellow sandy silty till of the Bloomington Drift. The Champaign Moraine is 2 to 3 miles wide, and its crest is generally 50 to 75 feet above the plain in front of the moraine. The Champaign Moraine appears to represent a larger than usual readvance of the Decatur Sublobe, because the truncation of five moraines at nearly right angles suggests a major reorientation of the ice front. If this readvance had a comparable movement in the Peoria Sublobe, it was overriden by the Bloomington readvance. The Champaign Moraine truncates the Le Roy Moraine but is truncated within 5 miles by the Bloomington Moraine.

Rantoul Drift (New)

The Rantoul Drift is named for Rantoul, Champaign County, and is based on the Rantoul Moraine (pl. 1). The moraine is truncated by the Illiana Morainic System at Rantoul, but it extends 15 miles southwestward, where it merges with the back slope of the Champaign Moraine. The ridge is about 2 miles wide and 50 feet high and has a well defined frontal slope on the west. The ridge may represent a temporary stand during retreat of the Champaign glacier. On the other hand, it may be a buried extension of the Cerro Gordo, Pesotum, or West Ridge Moraines, thinly mantled with Champaign Drift. If

the latter relation is confirmed, the name Rantoul Drift will not be needed.

Urbana Drift

The Urbana Drift, named for Urbana, Champaign County, is based on the Urbana Moraine (Ekblaw, 1960 revision of 1941 map) (pl. 1). The moraine was long mapped as part of the Champaign Moraine, but it clearly truncates the latter. It forms a continuous ridge from near Rantoul, where it is overridden by the Iliiana Morainic System, for about 50 miles to the Indiana state line. Its sharply lobate character and its overlapping relation to the Champaign, Ridge Farm, and Hildreth Moraines suggests that it represents a major readvance. It is generally 1 to 2 miles wide, and where it is most prominent south of Urbana it is 50 to 75 feet high. Near Rantoul and Fairmount, well developed but relatively short secondary ridges are included in the Urbana Moraine.

Illiana Drifts (New)

The Illiana Drifts are named for the village of Illiana on the Indiana state line northeast of Danville, Vermilion County, and are based on the Illiana Morainic System (pl. 1). The name is introduced for the Erie Lobe area as a replacement for Bloomington (Leverett, 1897), which is now restricted to the Lake Michigan Lobe drift. The Illiana Morainic System consists of two moraines—Newtown and Gifford—that are in contact throughout most of their 50-mile length, except near Danville where they are separated by tributaries of the Vermilion River. At the contact with the Lake Michigan Lobe drift, the moraines curve sharply northward, suggesting marginal interference of the ice sheets. Although there is much uncertainty about the relations in the interlobal complex, the Newtown Moraine almost certainly truncates the Bloomington Moraine, and the Gifford appears to truncate the Eureka, El Paso, and Minonk Moraines of the Lake Michigan Lobe, suggesting that the Illiana Drifts are at least slightly younger than the Bloomington and related drifts, which include at least one major readvance. The till in the Illiana Drifts, like that in the Bloomington, is in part pink to pinkish gray, which suggests that the apparent differences in age may not be great. However, it seems undesirable to continue use of the name Bloomington in the Decatur Sublobe, notwithstanding its long usage in both Illinois and Indiana.

Newtown Drift (New)

The Newtown Drift is named for the village of Newtown, Vermilion County, and is based on the Newtown Moraine (pl. 1), the outer moraine of the Illiana Morainic System. Newtown replaces the name Pilot (Leighton and Brophy, 1961), derived from Pilot Grove, which is on the Gifford Moraine rather than on the Newtown. The Newtown Moraine is 1 to 2 miles wide and its front rises sharply 50 to 75 feet, locally 100 feet, above the relatively flat plain in front. A widespread but generally thin sheet of outwash, which is part of the Newtown Drift, accounts for the flatness of the frontal plain.

Gifford Drift

The Gifford Drift, named for Gifford, Champaign County, is based on the Gifford Moraine (Leighton and Brophy, 1961) (pl. 1), the inner moraine of the Illiana Morainic System. The Gifford Moraine appears to represent a slight readvance of the glacier onto the back slope of the Newtown Moraine, and its crest is about the same height as that of the Newtown. However, the crest is less regular, and locally it consists of two parallel crests. The moraine is generally 2 to 4 miles wide.

Paxton Drift (New)

The Paxton Drift, named for Paxton, Ford County, is based on the Paxton Moraine (pl. 1). The moraine extends across the Decatur Sublobe from the Gibson City reentrant to the Indiana state line, about 55 miles. Although closely parallel to the Ellis Moraine behind it, it is only locally in contact with that moraine. The Paxton

Moraine previously was considered the frontal ridge of the Chatsworth Moraine, but the Paxton and the Ellis should be differentiated from the younger moraine on which the town of Chatsworth is located. The Paxton Moraine is about 50 miles long, 1 to 2 miles wide, and 50 to 75 feet high. It consists of gray clayey till.

Ellis Drift (New)

The Ellis Drift, named for Ellis, Vermilion County, is based on the Ellis Moraine (pl. 1). The moraine is about 45 miles long and 1 to 2 miles wide. A much weaker moraine than the Paxton, it is commonly only 20 to 40 feet high, but its continuity is well defined by parallel valleys that separate it from the Paxton and Chatsworth Moraines.

Chatsworth Drift

The Chatsworth Drift, named for Chatsworth, Livingston County, is based on the Chatsworth Moraine (pl. 1). Leverett, (1899a) called it the Chatsworth-Cayuga Ridge, and Leighton and Ekblaw (1932) shortened it to Chatsworth Moraine. In this report Chatsworth is restricted to the ridge on which the town of Chatsworth is located. It is a massive moraine, about 75 miles long in Illinois and 3 to 4 miles wide for most of its length. The crest is 50 to 75 feet high, generally near the front of the moraine, but it is less distinct and continuous than that of many moraines. The surface is generally rough and has sharper local relief than older moraines in the Decatur Sublobe. However, the moraine weakens eastward, and near the Indiana state line it is not as prominent as either the Paxton or Ellis Moraines. At the Gibson City reentrant, near Chatsworth, the Chatsworth Moraine appears to truncate both the Ellis and Paxton Moraines. With only slight reentrant it continues westward into the Peoria Sublobe, where it is truncated by the Marseilles Morainic System. The Farm Ridge Moraine, which emerges from beneath the Marseilles about 25 miles farther north, may be equivalent to the Chatsworth Moraine.

Gilman Drift (New)

The Gilman Drift, named for Gilman, Iroquois County, is based on the Gilman Moraine (pl. 1). The moraine is a weak, discontinuous ridge parallel to the Chatsworth Moraine and about 40 miles long. Although the moraine is 3 to 4 miles wide, it rises only 10 to 25 feet above the plain of glacial Lake Watseka. Thin patches of silty clay and sand on the moraine suggest that it was almost entirely covered by the lake, except at the extreme eastern end where it rises above the lake plain and has a normal morainal shape. Because the moraine is particularly weak in the middle, Leighton and Brophy (1961) applied the dual name Ashkum-Bryce, using names from both segments. The dual nomenclature is not needed, and it is replaced with Gilman from the central part of the moraine.

St. Anne Drift (New)

The St. Anne Drift, named for St. Anne, Kankakee County, is based on the St. Anne Moraine, a discontinuous ridge about 15 miles long that extends southeast from St. Anne to the front of the Iroquois Moraine (pl. 1). The moraine is about a mile wide and only 20 to 40 feet high, except for Mt. Langham, a sharp kame about 100 feet high at the northwest end of the ridge. The ridge is broken by outlet channels of Lake Watseka, and its lower areas are covered by lake sediments. The St. Anne Moraine has previously been considered part of the Marseilles Moraine because it contains greenish gray clayey till similar to that in the Marseilles Moraine and because Mt. Langham has been interpreted as a kame at the sharp reentrant in the front. However, the St. Anne Moraine may be equivalent to the Minooka Moraine, which has a similar till, or even to the Rockdale Moraine. If such is the case, the St. Anne Moraine should be included in the Lake Michigan Lobe, which is in keeping with the composition of the till. Because the morainic pattern is disrupted by the lake outlets and channels of the Kankakee Flood, the moraine is given a

separate name until its relations can be determined more definitely.

Iroquois Drift

The Iroquois Drift, named for Iroquois County, is based on the Iroquois Moraine (Leverett, 1899a) (pl. 1). The moraine appears to be the terminal deposit of a narrow lobe of ice that extended southwestward along the Kankakee Valley and penetrated about 8 miles into Illinois along a 15-mile front. The crest of the moraine is only 30 to 50 feet above the Lake Watseka plain, and the front is mantled with lake sediments and sand dunes blown from the lake plain. The till is largely yellow-gray, sandy, and silty, and is characterized by abundant boulders. In earlier years boulders covered many fields, but they have been hauled away and are now scarce. The drift clearly truncates the gray clayey till of the St. Anne Moraine. Farther east in Indiana the moraine is discontinuous and is mantled with lake and dune deposits, so that its occurrence as a distinct moraine has been questioned. Its relation to the Erie Lobe or the Saginaw Lobe also is controversial (Zumberge, 1960; Wayne and Zumberge, 1965). Although it usually has been assumed that the Iroquois Drift is equivalent to the Valparaiso Drift, the moraine is at least slightly older than the bordering lake deposits that are related to the Valparaiso maximum.

Lake Michigan Lobe

Peoria Sublobe Drifts

The Peoria Sublobe of the Lake Michigan Lobe is named for the city of Peoria, much of which is on the outermost moraines of the sublobe (fig. 12). It includes three morainic systems and 20 individual moraines that represent a minimum of 17 intervals of moraine building. The sublobe includes two major episodes of ice withdrawal and readvance before and following the building of the Bloomington Morainic System and one episode perhaps nearly as significant that occurred before the building of the Marseilles Morainic System. At all three times the readvance resulted in a major reorientation of the ice front and was accompanied by recognizable changes in the composition of the drift.

The drift of the four oldest moraines—Shelbyville, Le Roy, Shirley, and Kings Mill—contains gray tills and is part of the Delavan Member of the Wedron Formation. The three moraines of the Bloomington Morainic System contain pink sandy till, which is part of the Tiskilwa Member. The eight drifts—Normal through Chatsworth—are characterized by yellow-gray silty till and are part of the Malden Member. The three drifts of the Marseilles Morainic System are medium to dark gray clayey till and are part of the Yorkville Member.

In the area of the Marseilles Morainic System, the four lower members of the Wedron Formation are preserved locally in stratigraphic sequence. The persistence of the distinctive pink Tiskilwa Till, which characterizes the Bloomington Morainic System, beneath the Wadsworth Till, which characterizes the Vaparaiso Drift, suggests a readvance of as much as 100 miles. Similar evidence in this area suggests that the retreat prior to the glacial advance to the Bloomington Moraine may have been as much as 50 miles. Many of the intermediate readvances may have been 10 to 20 miles. Two or three of the moraines in this sublobe may represent recessional stands of the ice front without significant readvance.

Shelbyville Drift

The Shelbyville Drift continues from its type locality in the Decatur Sublobe into the Peoria Sublobe and extends about 35 miles to the Illinois Valley at East Peoria, where it is overlapped by Le Roy Drift (pl. 1). The Shelbyville Morainic System is undifferentiated in the Peoria Sublobe, although its height and its complex lobate front suggest that it consists of several overlapping drift sheets. Only about 5 miles northwest of the reentrant that marks the contact between the two lobes, the Le Roy Moraine rises on the Shelbyville and

apparently overlaps it in two small areas. The Shelbyville Moraine is 4 to 5 miles wide, but where it is partially overlapped by the Le Roy Moraine it is generally about a mile wide. The Shelbyville Moraine has a steep, strongly lobate front that rises 75 to 100 feet above the Illinoian till plain. The presence of the Le Roy Moraine near the crest of the Shelbyville adds a step about 50 feet high and makes the Wisconsinan morainic front facing the Havana Lowland a prominent feature. Both Shelbyville and Le Roy Drifts consist of gray, sandy till that is slightly pinkish in some localities.

Le Roy Drift

The Le Roy Drift, named for Le Roy, McLean County, is based on the Le Roy Moraine (Ekblaw, 1941) (pl. 1). The moraine is an inconspicuous east-west ridge 1 to 2 miles wide and 20 to 40 feet high in its type locality. It continues westward for about 30 miles from its terminus near the Champaign Moraine to southwest of Bloomington. From there it curves southward along the southwest side of Sugar Creek to the back slope of the Shelbyville Moraine. This segment is a weak ridge through the town of McLean, and the Le Roy glacier may have curved northwestward into the complex area of drift at the western end of the Shirley Moraine. A prominent escarpment southwest of McLean, frequently shown as the front of the moraine, appears to be an overridden erosional feature. If the Le Roy Moraine does not extend southwestward, the ridge along the Shelbyville crest may be equivalent to one of the moraines in the Shelbyville Morainic System farther southeast. Where it overlaps the Shelbyville Moraine, the Le Roy Moraine is relatively rough-surfaced and is 50 to 75 feet high and 2 to 3 miles wide.

Shirley Drift (New)

The Shirley Drift, named for Shirley, McLean County, is based on the Shirley Moraine (pl. 1). The moraine is a continuous ridge close to the Le Roy Moraine to the point where the latter curves southwestward to the Shelbyville Moraine. At that point the Shirley Moraine appears to turn northwestward and end at the front of the Bloomington Moraine. The moraine is about 25 miles long and about a mile wide. It is about 50 feet high at Shirley, but farther east it is more commonly 20 to 30 feet high. It consists of yellow-gray sandy till similar to that in the eastern part of the Bloomington Moraine immediately to the north.

Kings Mill Drift (New)

The Kings Mill Drift is based on the Kings Mill Moraine (pl. 1), a weak morainic ridge that occurs along the front of the Bloomington Morainic System for about 10 miles west of Sugar Creek at Bloomington, McLean County. It is named for Kings Mill Creek, which crosses its eastern end. It is only about a mile wide, and at its maximum is 40 feet high. It may represent a temporary expansion of ice during the building of the Bloomington Moraine, but the main Bloomington front is about a mile farther north.

Bloomington Drifts

The Bloomington Drifts, named for Bloomington, McLean County, are based on the Bloomington Morainic System (Leverett, 1897) (pl. 1). Although Leverett applied the name to all the drift from the Bloomington Moraine back to the Marseilles Moraine, it since has been restricted to the closely related moraines around the edge of the area, the major part of which is composed of pink till. The Bloomington drifts form one of the most conspicuous morainic features in Illinois. Because of overlapping relations and the erosional gap at the Illinois Valley, the moraines composing the morainic system have different names in different areas. In the type area the Bloomington Morainic System is not differentiated into named moraines, although, locally, double crests indicate its complex nature. Farther northwest, two distinct ridges behind the major front are differentiated—the Washington and Metamora Moraines. North of the

Illinois Valley, the morainic system is differentiated into three moraines, the Sheffield (oldest), Buda, and Providence Moraines, which are traceable to their type localities in the Princeton Sublobe. In the Peoria Sublobe, the Bloomington Morainic System completely overlaps the Shelbyville Morainic System north of the Illinois Valley. At Bloomington the crest of the morainic system is about 150 feet high, and north of Peoria it is as much as 200 feet locally. The till in the Bloomington Morainic System is characteristically a pink sandy till throughout the Peoria Sublobe northwest of the Mackinaw River. From there east to Bloomington it grades through pinkish gray to yellow-gray very sandy till that continues eastward to the end of the moraine in the Gibson City reentrant. In most localities the pinkish color of the till readily differentiates it from the older gray Woodfordian tills and from the yellow-tan to yellow-gray till of the younger Woodfordian deposits.

Washington Drift (New)

The Washington Drift, named for Washington, Tazewell County, is based on the Washington Moraine (pl. 1). The moraine is part of the Bloomington Morainic System. It extends southeast from the Metamora Moraine through Washington and has a well defined front for about 10 miles. Farther southeast the front is indistinct. The Washington Drift consists largely of pink till.

Metamora Drift

The Metamora Drift, named for Metamora, Woodford County, is based on the Metamora Moraine (Ekblaw, 1941) (pl. 1). The moraine is a well defined ridge 30 to 40 feet high, about a mile wide, and 10 miles long that extends slightly south of west from its truncation by the Eureka Moraine to the Illinois River Valley bluffs. Although it sharply truncates the Washington Moraine, it is considered part of the Bloomington Morainic System because of its probable continuity with the inner moraine of the Bloomington west of the Illinois Valley. The Metamora Drift consists largely of till that is a stronger pink than the till in the other Bloomington moraines east of the Illinois Valley.

Sheffield Drift

The Sheffield Drift, named for Sheffield, Bureau County, is based on the Sheffield Moraine (pl. 1). The moraine, with one small gap, is directly traceable to the type locality in the Princeton Sublobe (fig. 12). It is the outer of three moraines in the northernmost of two small lobate areas in the front of the Bloomington Morainic System north of the Illinois Valley. The relations in the reentrant between the two small lobes is not entirely clear, but the presence of only two moraines in the southern lobe suggests that the Sheffield is overlapped by the Buda. The Sheffield Moraine is 1 to 2 miles wide, about 15 miles long, and 50 to 75 feet high. The Sheffield Drift is largely sandy pink till.

Buda Drift

The Buda Drift, named for Buda, Bureau County, is based on the Buda Moraine, which is the middle of the three moraines of the Bloomington Morainic System north of Peoria (pl. 1). Although it is overlapped by the Providence Moraine in one small area, its continuity to the type locality in the Princeton Sublobe seems reasonably definite. In the southern of the two lobate areas, where it overlaps the Sheffield Moraine, it is the front of the drift of Wisconsinan age. It is commonly about 2 miles wide and its crest is 150 to 200 feet above the Illinoian till plain. The Buda Drift is largely sandy pink till.

Providence Drift

The Providence Drift takes its name from Providence, Bureau County, and is based on the Providence Moraine, the inner ridge of the Bloomington Morainic System north of Peoria. The moraine is continuous northward to its type locality in the Princeton Sublobe (pl. 1). It trends nearly north-south, showing only a slight response to the two lobate areas of the earlier moraines. Its

termination at the Illinois Valley bluffs is directly in line with the truncated Metamora Moraine on the east side of the valley, and the two moraines are probably equivalent. The Providence Moraine is 2 to 4 miles wide, about 50 feet high, and its drift consists largely of sandy pink till.

Normal Drift

The Normal Drift, named for Normal, McLean County, is based on the Normal Moraine (Leighton and Ekblaw, 1932), the first moraine behind the Bloomington Morainic System in the Peoria Sublobe (pl. 1). It extends westward from the Gibson City reentrant for about 35 miles and then is overlapped by the Eureka Moraine. The Normal Moraine is 1 to 3 miles wide. Its crest is generally 40 to 60 feet above the narrow valley separating it from the Bloomington Moraine, but it is 75 to 100 feet lower than the crest of the Bloomington Moraine. The Normal Drift is more clayey and less sandy than the Bloomington Drift, and it is the front of the gray drift that is included in the Malden Till Member of the Wedron Formation. The name Normal has previously been used to include the Eureka and Fletchers Moraines, and Leighton and Brophy (1961) extended it to include the moraines here called Dover and Paw Paw in the Princeton Sublobe.

Eureka Drift (New)

The Eureka Drift is named for Eureka, Woodford County, and is based on the Eureka Moraine (pl. 1). The moraine extends across the entire Peoria Sublobe, about 100 miles. It is 1 to 3 miles wide and commonly 40 to 60 feet high. It has a relief of about 100 feet northwest of Normal, where it overlaps the Normal Moraine, and was deposited on top of the Normal. The front has a sharp reentrant where the ice overrode the Metamora Moraine. In the broadened area of the moraine east of the reentrant, an east-west ridge a mile north of Roanoke, Woodford County, probably is an overridden extension of the Metamora Moraine. Preservation of such a ridge is not common, as most overridden moraines are cut away and do not retard the flow of ice sufficiently to form a reentrant. However, the Eureka Moraine, except where the Normal Moraine is present, is the outer limit of the Malden Till Member. In many areas the Malden Till is a relatively thin deposit, suggesting thin and mobile ice, which may account for the reentrant and for preservation of the buried ridge.

Fletchers Drift (New)

The Fletchers Drift is named for Fletchers, McLean County, which is on the Illinois Central Railroad 3 miles southwest of Cooksville. It is based on the Fletchers Moraine (pl. 1), a morainic area 3 to 4 miles wide that extends westward from the Gibson City reentrant for about 20 miles. Although previously included in the Normal Moraine, it has a distinct front, and a well defined frontal valley separates it from the Eureka Moraine. Its crest is 30 to 40 feet above the frontal valley.

El Paso Drift

The El Paso Drift, named for El Paso, Woodford County, is based on the El Paso Moraine (Leighton and Brophy, 1961) (pl. 1). It was called the Cropsey Ridge by Leverett (1899a) and the Outer Cropsey Moraine of the Cropsey Morainic System by Leighton and Ekblaw (1932). It extends westward from the Gibson City reentrant for about 50 miles, at which point it is overridden by the Varna Moraine. It is a well defined, continuous ridge, most of it 2 to 3 miles wide, but it is relatively low, only 30 to 40 feet high.

Varna Drift (New)

The Varna Drift, named for Varna, Marshall County, is based on the Varna Moraine (pl. 1). The moraine is overridden by the Minonk Moraine at its southern end. It extends northward for about 40 miles to the Illinois Valley bluffs, where it is partly overlapped by the Mt. Palatine Moraine. The Varna Moraine previously was called the Middle Cropsey Moraine (Ekblaw,

1941). Leighton and Brophy (1961) included it in the El Paso Moraine. It is 1 to 3 miles wide and generally only 20 to 30 feet high, except for a high of nearly 50 feet where it overlaps the El Paso Moraine. Although its continuation northward from the Illinois Valley bluffs near Hennepin is not certain, it most likely curves westward into the Princeton Sublobe and is equivalent to the Arispie Moraine south of Bureau Creek and to the Dover Moraine north of the creek.

Minonk Drift (New)

The Minonk Drift, named for Minonk, Woodford County, is based on the Minonk Moraine (pl. 1). The moraine was part of the Cropsey Morainic System, the northern part of which was called Inner Cropsey (Willman and Payne, 1942) and the southern part Middle Cropsey (Ekblaw, 1941). Leighton and Brophy (1961) restricted the name Cropsey to this moraine because the town of Cropsey, McLean County, is on it. They extended the name northward to include the Farm Ridge, Gilberts, and Marengo Moraines. Because Cropsey was also used for the El Paso, Varna, Minonk, Strawn, and Mt. Palatine Moraines, the confusion can best be resolved by discontinuing use of the name Cropsey. The Minonk Moraine is 2 to 4 miles wide and extends across the entire Peoria Sublobe, about 65 miles. Like the El Paso and Varna Moraines, it is not high; its crest is commonly 30 to 40 feet, rarely 50 feet, above the till plain in front. It differs from them in having a highly lobate front and a discontinuous, irregular crest.

Strawn Drift (New)

The Strawn Drift, named for Strawn, Livingston County, is based on the Strawn Moraine (pl. 1). The moraine is a weak morainic ridge between the Minonk and Chatsworth Moraines near the Gibson City reentrant. It weakens westward and is recognizable for only about 15 miles. It is 1 to 2 miles wide and 20 to 30 feet high. It previously was called part of the Inner Cropsey Moraine (Ekblaw, 1941).

Chatsworth Drift

The Chatsworth Moraine, although largely in the Decatur Sublobe (pl. 1), continues for about 25 miles into the Peoria Sublobe without notable change before it is overlapped by the Marseilles Morainic System. The Chatsworth is clearly older than the Cullom Moraine of the Marseilles and may be completely truncated by the Cullom at their contact rather than extending to the Ransom Moraine, as mapped. The Chatsworth Drift consists of the youngest part of the Malden Member of the Wedron Formation in the Peoria Sublobe.

Marseilles Drifts

The Marseilles Drifts, named for Marseilles, La Salle County, are based on the Marseilles Morainic System (Leverett, 1897) (pl. 1). The morainic system has generally been called the Marseilles Moraine, but its classification as a morainic system is reinstated here. The massive size of the moraine has been related to at least two overlapping drift sheets (Willman and Payne, 1942). The upper and most prominent part is here named the Ransom Moraine. Two moraines in different areas along the front may be contemporaneous, but they are named separately, the Norway and the Cullom.

The Marseilles Morainic System is one of the broader morainic systems, about 10 miles wide for over 50 miles. However, it tapers to a mile or two wide on the sides of the lobe, showing that the greater flow of ice and the greater amount of debris were transported along the axis of the lobe. This suggests that the ice front remained at least close to its maximum position longer than that of many other moraines. The crest of the morainic system is about 150 feet above the lake plains, which occur on both sides.

The Marseilles Drifts (Willman and Payne, 1942) are the youngest drifts in the Peoria Sublobe and have the youngest looking topography. The local relief is sharper than that of the older moraines, except possibly that of the Chatsworth, and many swamps and a few small lakes, rare

in older moraines, are present. The till in the Marseilles Morainic System is largely medium to dark gray and very clayey. It commonly contains an abundance of small dolomite pebbles that concentrate on weathered surfaces and give them the appearance of gravel. The Marseilles Drifts are part of the Yorkville Till Member of the Wedron Formation.

Exposures along the Illinois Valley, which cuts entirely through the moraine where the drift is thickest, show that the Marseilles Drifts are at least 100 feet thick and overlie drifts of the Malden, Tiskilwa, and Delavan Members.

The building of the Marseilles Morainic System marked the termination of the Princeton Sublobe, because the morainic system shows no effect of the westward lobation initiated by the Green River Sublobe, which continued through the deposition of the Princeton Sublobe. As the Marseilles Morainic System indicates a significant readvance, reorientation, and change in composition, it may become desirable to reclassify it as the front of a separate sublobe.

Norway Drift (New)

The Norway Drift, named for the village of Norway, La Salle County, is based on the Norway Moraine (pl. 1). The moraine is 1 to 2 miles wide, about 40 miles long, and generally rises 40 to 60 feet above the lake plain in front. It forms a distinct shelf-like area extending to the steeper front of the Ransom Moraine. On each side of the Illinois Valley it has a tongue-like extension that suggests a shallow channel had been eroded at the present site of the Illinois Valley when the Norway glacier reached that position. The channel must have been relatively shallow because the more massive Ransom Moraine crosses the valley without a suggestion of tonguing. The Norway Drift is probably equivalent to the St. Charles Drift that, farther north, diverges from the Marseilles, crosses the Fox Valley, and is part of the Princeton Sublobe. It probably is equivalent also to the Huntley Drift in the Harvard Sublobe.

Cullom Drift

The Cullom Drift, named for Cullom, Livingston County, is based on the Cullom Moraine (Leighton and Brophy, 1961) (pl. 1). The moraine occupies a position similar to that of the Norway Moraine for about 35 miles along the southern side of the Marseilles Morainic System. It is slightly farther removed from the Ransom Moraine, except at both ends where it is overlapped by the Ransom. It is 1 to 3 miles wide, generally about 50 feet high, and has relatively strong local relief.

Ransom Drift (New)

The Ransom Drift, named for Ransom, La Salle County, is based on the Ransom Moraine (pl. 1). The moraine was formerly called the Inner Marseilles Moraine (Willman and Payne, 1942). It is about 100 miles long and 6 to 8 miles wide, but it tapers to a mile wide at the ends. Its crest is generally 50 to 100 feet higher than the crests of the Norway and Cullom Moraines. Although they are separated by about 30 miles, their similarity in stratigraphic position and composition suggest that the Ransom Drift is equivalent to the Barlina Drift in the Harvard Sublobe.

Drifts of the Green River and Dixon Sublobes

Patches of relatively weak end moraine are preserved along the margins of the Green River and Dixon Sublobes (fig. 12), and they serve as a basis for morphostratigraphic units in local areas. Most of the drift of the Green River Sublobe is covered with outwash and dune sand, and no readvances have been recognized in it or in the Dixon Sublobe. The following units have been differentiated.

Harrisville Drift (New)

The Harrisville Drift is named for Harrisville, Winnebago County, 4 miles south of Rockford, and is based on the Harrisville Moraine, an area with local morainic ridges along the north side of the Dixon Sublobe. The drift is largely gray clayey till. It

is included in the Esmond Till Member of the Wedron Formation (Frye et al., 1969).

Temperance Hill Drift (New)

The Temperance Hill Drift is named for Temperance Hill School 3 miles northwest of Lee Center, Lee County, and is based on the Temperance Hill Moraine, which was mapped by Knappen (1926). It is a smooth-surfaced ridge about 12 miles long, a mile wide, and 40 to 50 feet high. It consists largely of gray sandy till that is included in the Lee Center Till Member of the Wedron Formation (Frye et al., 1969).

Atkinson Drift (New)

The Atkinson Drift is named for Atkinson, Henry County, and is based on the Atkinson Moraine, which consists of patches of morainic topography on the south side of the Green River Sublobe. In that area the margin of the glacier was against the south wall of the Ancient Mississippi Valley, which is the south side of the Green River Lowland. The morainic area was partly submerged by outwash from the glacier during the building of the Bloomington Morainic System. The drift is largely gray sandy till and is included in the Lee Center Member of the Wedron Formation (Frye et al., 1969).

Princeton Sublobe Drifts

The moraines of the Princeton Sublobe (fig. 12) retain the shape initiated by the westward spread of the glaciers up the Ancient Mississippi Valley. The sublobe includes one morainic system, the Bloomington, 16 named moraines, and the Elburn Complex in which several discontinuous and variously oriented moraines are not differentiated. Some of the moraines may be contemporaneous, but a minimum of 12 episodes of moraine building is required.

The complexity of names in the sublobe results from the uncertain relations of several of the moraines. In a reentrant about 8 miles northeast of Princeton, Bureau County, the Dover Moraine from the south makes a sharp curve eastward and terminates in such a way that it could be equivalent to any one of five moraines—Van Orin, Theiss, La Moille, Paw Paw, or Arlington—or it could be older than all of them (pl. 1). The Arlington seems to be a continuous ridge extending southward behind the Dover, and it is the least likely to be equivalent to the Dover. The Van Orin and Theiss Moraines are composed largely of pink till of the Tiskilwa Member, whereas the Dover is the front moraine of the yellow-tan Malden Till Member. Both the Paw Paw and La Moille Moraines appear to have a core of Tiskilwa Till mantled at least in places by the Malden Till, which is not known to be the case in the Dover Moraine. It seems most likely that the Dover correlates with the Shabbona Moraine, 30 miles northeast. Neither has a distinctive end moraine where it overlaps the older moraines composed of Tiskilwa Till.

Only the moraines of the Bloomington Morainic System continue southward into the Peoria Sublobe, and none are definitely traced into the Harvard Sublobe. As in the Peoria Sublobe, the drift of the Princeton Sublobe includes four till members of the Wedron Formation. The basal drift with gray tills is the Lee Center Till Member, except in the extreme northern part east of the Dixon Sublobe, where it is the Esmond Till Member. These members are the surface drift west of the Princeton Sublobe. Eight named moraines of the Bloomington Morainic System are composed of pink tills of the Tiskilwa Till Member, but because of overlaps these may represent only five separate intervals of moraine building. The overlying Malden Till Member, characterized by yellow-gray silty till, constitutes six named moraines that represent at least four separate stands of the ice front. The youngest till member, the Yorkville, is present only in the St. Charles Moraine, which is gray clayey till. The contact between the Tiskilwa and Malden Till Members is traceable through the Elburn Complex by the lithology of the tills rather than along a morainic front. No extra cycles of readvance appear to be required to explain

the Elburn Complex. The irregularity and discontinuity of morainic ridges in the complex appears to result from the interaction of glaciers at the junction of the Princeton and Harvard Sublobes.

On readvancing after the major retreat from the Bloomington Morainic System, the ice front did not retain the slightly lobate shape of the Bloomington. Consequently, it first encountered the massive Bloomington Moraine at the reentrant near Mendota. In that area the ice mounted the back slope of the Bloomington and deposited the yellow-tan till of the Malden Member. At its most advanced position it deposited a thin mantle of the till on the Paw Paw and La Moille Moraines, and locally on the Theiss Moraine, apparently without greatly modifying the original hummocky topography. This may have been a very brief advance of thin ice, because the outer margin of the Malden Till Member in the low area to the northeast is the very weak Shabbona Moraine. In several other regions the initial deposit of the Malden Member is thin, and its margin is represented by a relatively weak moraine.

Bloomington Drifts

The Bloomington Morainic System (pl. 1) forms the front of the Princeton Sublobe for about 100 miles and is traced, except for the gap at the Illinois Valley, to its type locality in the Peoria Sublobe. The Bloomington Morainic System in the Princeton Sublobe consists of successive sheets of drift forming a prominent moraine that rises 150 to 200 feet above the Green River Lowland. To the south it consists of three moraines, Sheffield, Buda, and Providence, but in its northern part it has four moraines, Shaws, Providence, La Moille, and Paw Paw. Near the middle of the Princeton Sublobe, the Bloomington has a reentrant that is a weak reflection of the differentiation of the earlier glaciers into the Green River and Dixon Sublobes. The Bloomington Drifts are characterized by sandy pink till.

Although the morainic system is clearly separated from the younger moraines at the north and south ends, the differentiation is indefinite in the middle part, where several moraines converge and are closely spaced on the back slope of the Bloomington. For the present it appears preferable to limit the Bloomington Morainic System to the inner limit of the Providence Moraine as far northeast as the reentrant, but to include the La Moille and Paw Paw Moraines north of there, as they have previously been included in the Bloomington. The Van Orin and Theiss Moraines occur high on the Bloomington and, like it, consist largely of pink till. They may be recessional ridges formed during withdrawal from the Bloomington, but they clearly diverge from it southward. The La Moille and Paw Paw Moraines also are composed largely of pink till in the reentrant area, but they are mantled by a thin cover of yellow sand and silty till that appears to be an outer overlapping fringe of the Malden Till Member, similar to that composing the Dover, Shabbona, Arlington, and younger moraines. Farther southwest the La Moille and Paw Paw Moraines also diverge from the Bloomington Morainic System.

Sheffield Drift

The Sheffield Drift, named for Sheffield, Bureau County, is based on the Sheffield Moraine (MacClintock and Willman, 1959), which is the outer moraine of the Bloomington Morainic System (pl. 1). It extends for about 40 miles and is 1 to 2 miles wide. It is 60 to 80 feet high, locally more than 100 feet, as at Walnut, Bureau County. It has a rough topography with sharp relief. The Sheffield Moraine may be equivalent to the Shaws Moraine, which forms the front of the Bloomington Drift north of the overlap south of Amboy. However, only one moraine is differentiated outside the Providence in that area, and the Shaws may be equivalent to the Buda Moraine.

Buda Drift

The Buda Drift, named for Buda, Bureau County, is based on the Buda Moraine (MacClintock and Willman, 1959), which is the middle moraine of the Bloomington

Morainic System throughout the same area as the Sheffield (pl. 1). Although separate from the Sheffield and Providence Moraines in its type area, farther north the Buda is essentially a step-like area, rarely more than a mile wide, leading to the steep front of the Providence Moraine. A distinct but low crest is commonly present and is the principal basis for tracing the moraine. However, overlapping relations make mapping indefinite in many places.

Shaws Drift (New)

The Shaws Drift, named for Shaws, Lee County, a small village 4 miles east of Amboy (pl. 1), is based on the Shaws Moraine, which is the outer moraine of the Bloomington Morainic System in the northern part of the Princeton Sublobe (pl. 1). It is differentiated in two areas, the southern part about 10 miles long, the northern 15 miles long. In the intervening 8 miles, several prominent noses or benches suggest that the Shaws is not entirely overlapped by the Providence Moraine. The moraine is generally a mile or less wide and 50 to 100 feet high. It generally has a low crest. It is probably equivalent to either the Sheffield or Buda Moraines, or both may be represented in the two areas mapped as Shaws Moraine.

Providence Drift

The Providence Drift, named for the village of Providence, Bureau County, is based on the Providence Moraine (MacClintock and Willman, 1959), which is the inner moraine of the Bloomington Morainic System in the southern part of the Princeton Sublobe (pl. 1). The Providence Moraine is the most prominent of the ridges in the morainic system, generally rising 100 feet or more above the moraines in front. South of Amboy the ridges forming the moraine crest turn northward into a lobate area 1 to 2 miles wide and 4 miles long that appears to represent an extension of the Providence glacier across the Buda and Sheffield Moraines. The relations are masked by sand dunes blown from the Green River Lowland and require more detailed study. The moraine has greater and sharper relief than younger moraines in the sublobe. Small lakes and swampy depressions are common locally in the broader areas. Where the moraine crosses Princeton Valley, the partially buried valley of the Ancient Mississippi River, its surface is about 200 feet lower for nearly 8 miles. The preservation of exceptionally fresh-looking kames, eskers, kettle holes, and ice-front deltas in the area south and west of Wyanet, Bureau County, suggests that, during withdrawal of the ice from the moraine, a detached segment of the glacier remained in the valley and dissipated by stagnation.

Van Orin Drift (New)

The Van Orin Drift, named for Van Orin, Bureau County, is based on the Van Orin Moraine (misspelled Van Orion on pl. 1), which is a well defined ridge about 10 miles long, a mile wide, and rises about 50 feet above the valleys on either side. To the northeast the moraine appears to blend into the back slope of the Providence Moraine. Southwestward it terminates sharply at the relatively flat groundmoraine behind the Providence, but the moraine may have curved southward and, if so, it was overlapped by the Theiss Moraine. It consists of pink till of the Tiskilwa Till Member.

Theiss Drift (New)

The Theiss Drift, named for Theiss Cemetery 3 miles southwest of Sublette, Lee County, is based on the Theiss Moraine (pl. 1). The moraine is 16 miles long, 1 to 2 miles wide, and 40 to 50 feet high, except at the northeast end where it appears to blend into the back slope of the Providence Moraine. It consists largely of the pink till of the Tiskilwa Till Member, but locally it has a thin cover of yellow-gray till of the Malden Till Member.

La Moille Drift (New)

The La Moille Drift, named for La Moille, Bureau County, is based on the

La Moille Moraine (pl. 1). The moraine is a narrow ridge, rarely more than a mile wide, but traceable for 50 miles. In the region southwest of Paw Paw, it generally is a well defined ridge 30 to 40 feet high, with valleys separating it from adjacent moraines. In several areas it becomes quite weak and may be overlapped by the Paw Paw Moraine. It appears to have a core of pink till of the Tiskilwa Till Member, but in numerous shallow borings a mantle of yellow-gray till of the Malden Member was encountered. Near Paw Paw, the ridge appears to curve northward and continue as a ridge of the Bloomington Morainic System, and to the north the pink till is not mantled by the Malden Member.

Paw Paw Drift (New)

The Paw Paw Drift, named for Paw Paw, Lee County, is based on the Paw Paw Moraine (pl. 1). The moraine is traced for about 50 miles and generally is 1 to 2 miles wide. It is a more prominent ridge than the La Moille, except in the northern region, west of De Kalb, where it locally becomes weak and is difficult to trace. North of the reentrant near Paw Paw, it consists largely of pink to pinkish gray till of the Tiskilwa Till Member, whereas in the area to the southwest the Tiskilwa Till has a thin cover of yellow-gray till of the Malden Member. North of the area where the Malden Till Member is recognized, thick yellow-gray silts, locally present on the moraine, appear to be ice-block lake deposits. The back slope of the Paw Paw Moraine and the area it encloses south to the Shabbona Moraine is a relatively flat surface, except for numerous shallow depressions with sharp relief, the preservation of which suggest that the Bloomington ice in that area dissipated by stagnation.

Shabbona Drift (New)

The Shabbona Drift, named for Shabbona, De Kalb County, is based on the Shabbona Moraine (pl. 1), a weakly morainic area 1 to 2 miles wide that extends for about 18 miles along the front of the more prominent Arlington Moraine. The Shabbona Moraine is the front of the yellow-tan to gray drift of the Malden Till Member. Although the moraine as a distinct topographic feature extends southwestward from Shabbona for only about a mile, the distinctive till continues in that direction as a thin mantle on the Paw Paw Moraine. Eastward it continues to the Elburn Complex, within which it is not recognizable as a topographic feature. However, the approximate position of the ice front is shown by the margin of the Malden Till Member.

Dover Drift

The Dover Drift, named for Dover, Bureau County, is based on the Dover Moraine (Cady, 1919) (pl. 1). The moraine is a smooth-surfaced ridge about 12 miles long, 1 to 2 miles wide, and 30 to 40 feet high. Its front is the boundary of the Malden Till Member in this part of the lobe. Northward its continuation is uncertain, as previously mentioned, but it probably is equivalent to the Shabbona Moraine. Southward it is truncated by Bureau Creek, south of which it appears to correlate with the Arispie Moraine.

Arispie Drift (New)

The Arispie Drift, named for Arispie Township, Bureau County, is based on the Arispie Moraine (pl. 1). The moraine is an east-west ridge only 4 miles long, 1 mile wide, and 20 to 30 feet high, on the south side of Bureau Creek. At its east end it is truncated by the Illinois Valley. At its west end it appears to cut across the north end of the Eureka Moraine, previously called the Normal Moraine in this area. The Arispie appears to be a link between the Dover Moraine and the Varna Moraine of the Peoria Sublobe, but Leighton and Brophy (1961) considered this ridge a local feature and correlated the Eureka (then called Normal) Moraine with the Dover Moraine. Although the front of the Eureka and Dover Moraines is the contact of the Malden and Tiskilwa Till Members, this correlation is not consistent with the shapes of both older and younger

moraines, and it does not account for the Arispie or Varna Moraines. Although it is short and weak, the Arispie is named separately because of the uncertainty concerning its correlation.

Arlington Drift

The Arlington Drift, named for Arlington, Bureau County, is based on the Arlington Moraine (Cady, 1919) (pl. 1). The moraine extends for about 55 miles and is generally 1 to 3 miles wide. From 2 miles west of Shabbona nearly to Arlington, the moraine appears to be perched on the steep back slope of the Bloomington Morainic System, giving it a maximum relief of about 150 feet at Mendota. However, the crest of the moraine at the top of the steep slope rises only 30 to 40 feet above the frontal valley separating it from the Paw Paw Moraine, which is a better indication of the thickness of the drift in the moraine. East of the area of involvement with the Bloomington Moraine, it descends to a relatively flat plain and is a readily traceable ridge with sharp local relief and a height of 40 to 50 feet. It continues eastward to the Elburn Complex, where it sharply decreases in size to an indistinct ridge traceable with difficulty eastward to Elburn. In this region the Arlington Moraine has previously been called the Elburn Moraine. From Arlington southwest to its truncation by the Illinois Valley, it has a smooth surface and rises about 50 feet above the plain on either side. The Arlington Moraine appears to be equivalent to the Mt. Palatine Moraine south of the Illinois Valley.

Mt. Palatine Drift

The Mt. Palatine Drift, named for Mt. Palatine, Putnam County, is based on the Mt. Palatine Moraine (Leighton and Brophy, 1961) (pl. 1). The moraine is about 2 miles wide and extends southeastward from the bluffs at the Big Bend of the Illinois Valley for 15 miles to the vicinity of Lostant, where it is truncated by the Minonk Moraine. Its crest is 50 to 75 feet above the plain in front of the moraine. The drift consists largely of gray silty till. The moraine probably correlates with the Arlington Moraine north of the Illinois Valley. It has been previously correlated with both the Middle and Inner Cropsey Moraines, but, as it overlaps the Varna Moraine and is truncated by the Minonk at the contact between the Peoria and Princeton Sublobes, it apparently has no equivalent to the south, suggesting that pulses of the ice front in the two sublobes were not synchronous.

Mendota Drift (New)

The Mendota Drift, named for Mendota, La Salle County, is based on the Mendota Moraine (pl. 1). The moraine is a weakly morainic ridge about a mile wide that extends for about 40 miles along the base of the steep back slope of the Arlington Moraine. It generally has a crest of isolated hills and short ridges rising 20 to 30 feet above the shallow sag between it and the Arlington Moraine.

Farm Ridge Drift

The Farm Ridge Drift, named for Farm Ridge, La Salle County, is based on the Farm Ridge Moraine (pl. 1). The moraine was named by Leverett (1899a), who referred to the town as "Farm Ridge or Grand Ridge." The town name is now Grand Ridge. The Farm Ridge Moraine is 1 to 2 miles wide and its crest is 30 to 40 feet high. It consists of two segments, one about 35 miles long north of the Illinois Valley, the other about 15 miles long south of the valley. Northward it terminates at the Elburn Complex; southward it curves to the east and is truncated by the Marseilles Morainic System at nearly right angles. It appears to have truncated the Minonk Moraine of the Peoria Sublobe along the Vermilion River, giving a relation parallel to that of the Mt. Palatine Moraine. The character of the Farm Ridge Drift has been described by Willman and Payne (1942).

Elburn Drift (New)

The Elburn Drift, named for Elburn, Kane County, is based on the Elburn Com-

plex (pl. 1), an area complicated by short and variously oriented morainic ridges intermixed with kames, eskers, and lake basins. It embraces the area of conflict between the Princeton and Harvard Sublobes, and much of the irregularity may have been caused by stagnation of large segments of the ice in the reentrant between the lobes. The northern part of the morainic complex contains pink till of the Tiskilwa Member, and the southern part contains yellow-gray till of the Malden Member.

St. Charles Drift (New)

The St. Charles Drift, named for St. Charles, Kane County, is based on the St. Charles Moraine (pl. 1). The St. Charles Moraine is a weak and poorly defined morainic area that extends northeastward about 25 miles from the front of the Marseilles Moraine, west of Yorkville, almost to St. Charles, where it is overridden by the Minooka Moraine. Its front is the contact of the medium to dark gray clayey till of the Yorkville Till Member with the yellow-gray silty till of the Malden Till Member. The moraine is broken into disconnected areas by channels filled with younger outwash, and it is traced largely on the basis of the character of the till. It is included in the Princeton Sublobe because of its position east of the Elburn Complex, but it does not extend far enough southward to demonstrate that it had a lobate form like other moraines of the Princeton Sublobe, and it perhaps could be as easily assigned to the Peoria Sublobe.

Harvard Sublobe Drifts

The Harvard Sublobe (fig. 12) consists of the group of moraines that have a slight westward bulge north of the Princeton Sublobe and west of the Joliet Sublobe. It consists of six moraines that contain drift of four members of the Wedron Formation. The outermost moraine, the massive Marengo Moraine, consists of the pink till of the Tiskilwa Member. The Gilberts Moraine contains yellow to pinkish gray till and is a pinkish phase of the Malden Till Member. The Huntley and Barlina Moraines contain the gray clayey till of the Yorkville Till Member, and the West Chicago and Cary Moraines, part of the Valparaiso Morainic System, contain the silty to gravelly gray till of the Haeger Till Member. The tills of the Marengo, Gilberts, Huntley, and Barlina Drifts can be seen in sequence along the Algonquin-Huntley Highway a mile west of Algonquin.

Marengo Drift

The Marengo Drift (Leverett 1899a), named for Marengo, McHenry County, is based on the Marengo Moraine (pl. 1), the outermost moraine in the Harvard Sublobe. The moraine, commonly referred to as Marengo Ridge, is about 40 miles long and 3 miles wide. It is one of the higher moraines in Illinois, its crest commonly 150 feet and locally 200 feet above the outwash plain in front of the moraine. It is a rough-surfaced moraine composed largely of pink till similar to the till in the Bloomington Morainic System but of a stronger or deeper pink. The relation of the Marengo Moraine to the Bloomington is partly masked by the intervening Elburn Complex. Although the Marengo Moraine has commonly been correlated with the Bloomington, it appears to truncate the three Bloomington moraines and the area of ground-moraine behind them. It is, in effect, truncated at the south end by the younger drift of the Malden Till Member, which makes it at least equivalent to the younger part of the Bloomington. The sharp southern termination of the Marengo Moraine suggests that it was cut away by the glacier that deposited the thin Malden Till Member.

Gilberts Drift

The Gilberts Drift, named for Gilberts, Kane County, is based on the Gilberts Moraine (Leighton and Ekblaw, 1932) (pl. 1). The moraine consists of a low morainic area behind the Marengo Moraine, about 30 miles long and as much as 6 miles wide. It differs from the Marengo by the color of its till, which is yellow-gray to pinkish gray, much less pink than the Marengo. A slight change in topography shows where

the Gilberts ice slightly mounted the back slope of the Marengo Moraine and then stagnated without building an end moraine. The drift is sheet-like and not a ridge. It has a rough and fresh-looking topography. Morainic hills are intermixed with kames and eskers, and flat lake plains surround many of the hills. The moraine is terminated at the north end by being successively overlapped by the Huntley, Barlina, and West Chicago Moraines. Southward it grades into the eastern part of the Elburn Complex, which is composed of the Malden Till Member.

Huntley Drift

The Huntley Drift, named for Huntley, McHenry County, is based on the Huntley Moraine (Leighton and Willman, 1953) (pl. 1). The moraine is a low ridge about 8 miles long, most of it less than a mile wide, and 20 to 40 feet high. Its front is the outer margin of the Yorkville Member of the Wedron Formation in the Harvard Sublobe. Its gray clayey till is slightly more silty and lighter in color than the till in the Barlina Moraine, suggesting incorporation of Gilberts Drift during the Huntley readvance. The Huntley and Barlina Drifts are correlated with the Marseilles Drift. They were called Kishwaukee by Leighton and Ekblaw (1932) and later were called Marseilles (Leighton and others, *in* Willman and Payne, 1942).

Barlina Drift (New)

The Barlina Drift, named for Barlina Road, northwest of Lake-in-the-Hills, McHenry County, is based on the Barlina Moraine (pl. 1). The moraine is a rough-surfaced ridge about 16 miles long, 2 to 3 miles wide, and 20 to 40 feet high. The drift is largely gray clayey till characteristic of the Yorkville Till Member. It is truncated by the West Chicago Moraine at both ends. It previously was called the Marseilles Moraine.

Valparaiso Drifts

The Valparaiso Morainic System (pl. 1) is largely in the Joliet Sublobe (fig. 12), but the West Chicago and Cary Moraines curve northwestward into the Harvard Sublobe. The Valparaiso has a rough and young-looking morainic topography. It is relatively thin and is part of the Haeger Member of the Wedron Formation.

West Chicago Drift

The West Chicago Drift, named for West Chicago, Du Page County, is based on the West Chicago Moraine (pl. 1) and is traced to the type area in the Joliet Sublobe. In the Harvard Sublobe it is a relatively thin drift, consisting largely of pebbly silty till characteristic of the Haeger Member of the Wedron Formation. In places it is a gravelly till. It is readily distinguished from the clayey till of the Huntley and Barlina Drifts and from the pink till of the Marengo Drift, which it overlaps. At its northern end it rises on the back slope of the Marengo Moraine, and there is a striking contrast between the very rough knob and kettle topography of the West Chicago Drift with its many poorly drained depressions and small lakes, and the more rounded, generally larger hills of the Marengo Moraine. At Harvard a tongue of West Chicago Drift protrudes through a gap in the Marengo Moraine about a mile wide and 2 miles long. The tongue is mostly gravel but the abundance of large kettles and the local presence of till suggest that the ice temporarily filled the gap before or during the building of the moraine just east of the gap. North of the gap at Harvard, the West Chicago Moraine rises onto the crest of the Marengo Moraine, and it nearly overlaps the ridge before reaching the Wisconsin state line. For a few miles east of Woodstock, the moraine is broken by outwash plains, lake basins, and kame complexes, and its boundary with the younger Cary Drift is obscure.

Cary Drift

The Cary Drift, named for Cary, McHenry County, is based on the Cary Moraine (Leighton, 1925b) (pl. 1). The moraine was renamed Monee (Powers and Ekblaw, 1940) to avoid conflict with the use of Cary for a substage. Ekblaw (*in*

Suter et al., 1959) reinstated Cary for the moraine, and as Cary has been discontinued as a substage term (Frye and Willman, 1960), Cary is retained for the moraine. The Cary Moraine consists largely of till similar to that in the West Chicago Moraine and is part of the Haeger Member. It is a well defined moraine in its type locality at the boundary between the Harvard and Joliet Sublobes. Northwestward in the Harvard Sublobe it extends for 25 miles to the Wisconsin state line. It consists of isolated morainic areas separated by outwash channels. Outwash plains along its front indicate at least a temporary stand of the ice, but the mapping of the front is questionable in several areas. Many of the features along the moraine and in the area back of it to the Fox Lake Moraine appear to be buried ridges and valleys mantled by thin Cary Drift.

Joliet Sublobe Drifts

The moraines of the Joliet Sublobe (fig. 12) conform to the outline of the Lake Michigan Basin and show only local and low-angle overlaps. The lobe contains two morainic systems and 19 named moraines, which represent a minimum of 15 episodes of moraine building. The Minooka, Rockdale, Wilton Center, and Manhattan Drifts are largely clayey till that is part of the Yorkville Till Member of the Wedron Formation. The Fox Lake and Cary Drifts and the northern part of the West Chicago Drift consist largely of silty to gravelly till that is part of the Haeger Till Member. The remainder of the Valparaiso moraines, the Tinley Moraine, and the Lake Border Moraines consist of clayey till that is part of the Wadsworth Till Member. The differentiation of the Wadsworth and Yorkville Members south of the area in which the Haeger Member separates them is based on the slightly higher siltiness and greater abundance of gravel lenses in the West Chicago Drift, although much of the drift is clayey till.

Minooka Drift

The Minooka Drift, named for Minooka, Grundy County, is based on the Minooka Moraine (Leverett, 1897), which is the outermost ridge of the Joliet Sublobe for about 50 miles. The moraine is largely a well defined ridge about a mile wide and 60 to 80 feet high. At its southern end it is sharply truncated by the Des Plaines River. In the southern 10 miles the moraine has a relatively flat crest, and, as the crest is below the level of Lake Waupon-see (fig. 9), it probably was flattened by wave erosion. Several isolated morainic hills across the valley east of the southern end of the moraine that continue southeastward toward Kankakee have previously been assigned to the Minooka. As they are more directly in line with the Rockdale Moraine, they are here assigned to the Rockdale. However, their spread is such that they may also include remnants of the Minooka. The Minooka Drift is largely a very clayey, medium to dark gray till similar to that in the Marseilles Morainic System and is included with the Marseilles in the Yorkville Till Member of the Wedron Formation. It contains fewer pebbles than the Marseilles and much of it is darker in color and slightly more clayey than the Rockdale, Wilton Center, and Manhattan Drifts, which are also included in the Yorkville Member.

Rockdale Drift

The Rockdale Drift, named for Rockdale, Will County, is based on the Rockdale Moraine (Fisher, 1925) (pl. 1). The moraine has a well defined front for about 15 miles north of Rockdale. It is about 3 miles wide and rises 40 to 50 feet above the bottomland along the Du Page River. It extends about 25 miles south of the Illinois Valley and consists of isolated morainic areas rising above the surface of the Lake Wauponsee plain.

Wilton Center Drift (New)

The Wilton Center Drift, named for Wilton Center, Will County, is based on the Wilton Center Moraine (pl. 1). The moraine is a narrow, well defined ridge about a mile wide and 40 feet high in its

northern part, but at Wilton Center it broadens to as much as 7 miles and extends 25 miles to the Indiana state line. Although the front is readily traced eastward to the Kankakee Valley, where it is steepened by erosion, the morainic topography east of Peotone is weak. The broadened area may include equivalents of the Manhattan Moraine, but a second front or crest has not been traced through the area. The entire moraine has previously been included in the Manhattan Moraine.

Manhattan Drift

The Manhattan Drift, named for Manhattan, Will County, is based on the Manhattan Moraine (Fisher and Ekblaw, *in* Fisher, 1925) (pl. 1). The moraine extends from Joliet southeastward for about 20 miles. It has a well defined front near Manhattan and rises 40 to 50 feet above the sag between it and the Wilton Center Moraine. Its eastern margin is not definite and it may blend into the back part of the Wilton Center Moraine.

Valparaiso Drifts

The Valparaiso Drifts, named for Valparaiso, Indiana, are based on the Valparaiso Morainic System (Leverett, 1897, from manuscript by L. C. Wooster) (pl. 1). The Valparaiso previously was called the "moraine of the Lake Michigan glacier" by Chamberlin (1882). Where relations to the older drift are exposed along the Des Plaines Valley and the Sag Channel, the drift is relatively thin, mantling a rough surface (Bretz, 1955). The northern part has a very rough surface, with many lakes, lake basins partially filled with peat, and numerous kames and eskers. The middle and southern parts have strong local relief, but lakes are scarce. The system is 30 miles wide at the Wisconsin state line because of the westward bulge into the Harvard Sublobe, but the part in the Joliet Sublobe is 12 miles wide. Through most of its extent in Illinois the Valparaiso Morainic System is about 8 miles wide.

At the north end, the Fox Lake, Cary, and West Chicago Drifts are included in the Haeger Member of the Wedron Formation. The drifts of the remaining part of the morainic system belong to the Wadsworth Member.

In the northern part of the morainic system, the central and eastern sections have no traceable morainic ridges or crests, and the drift is referred to as Valparaiso undifferentiated. In the middle and southern parts, morainic fronts or crests are present in a few areas (Leighton, *in* Leighton and Willman, 1953; Ekblaw, *in* Suter et al., 1959; Leighton and Brophy, 1961), but they are connected along the moraine with considerable uncertainty. South of the Des Plaines Valley, they are recognized by morainic topography descending into and partially blocking the valleys. Between the valleys the boundaries are commonly placed at the front of higher hills, stream diversions, and ice front lakes or swamps. The moraines appear to represent minor pulses in retreat of the ice front, probably with slight readvance, and they account for the formation of an unusually broad morainic belt.

West Chicago Drift

The West Chicago Drift, named for West Chicago, Du Page County, is based on the West Chicago Moraine (Leighton, 1925b) (pl. 1). The West Chicago Moraine is the front ridge of the Valparaiso Morainic System in the Joliet Sublobe, and is the one moraine continuously present from the Harvard Sublobe to the Indiana state line, about 80 miles. The moraine is 1 to 3 miles wide, and its crest is commonly 40 to 50 feet high. The front is easily traced and is marked by a distinct increase in roughness of the topography, but it generally is not as steep as the fronts of many of the older Woodfordian moraines.

Cary Drift

The Cary Moraine, described under the Harvard Sublobe, is located at the contact of the Joliet and Harvard Sublobes (pl. 1). The major part is in the Harvard Sublobe, but the moraine continues southward from Cary for about 6 miles. At the southern

end it blends into the area mapped as Valparaiso undifferentiated. It is about a mile wide and has a rough topography, with individual hills 50 to 60 feet high.

Fox Lake Drift

The Fox Lake Drift, named for Fox Lake, Lake County, is based on the Fox Lake Moraine (Powers and Ekblaw, 1940) (pl. 1). The moraine is a kame-moraine, 2 to 3 miles wide and about 25 miles long. Most of the hills consist largely of gravel, and the drift, therefore, is included in the Haeger Till Member of the Wedron Formation. However, in some exposures the till is clayey and more like the till of the Wadsworth Till Member. The surface of the extensive outwash plains along the front of the moraine is higher than that of most of the kames in the moraine, which suggests an ice stand with rapid melting and final dissipation by stagnation. The moraine ends by blending into the undifferentiated Valparaiso Drift to the south.

Wheaton Drift

The Wheaton Drift, named for Wheaton, Du Page County, is based on the Wheaton Moraine (Ekblaw, *in* Suter et al., 1959) (pl. 1). The Wheaton Moraine is the first moraine back of the West Chicago Moraine from about 5 miles north of Wheaton southeast to the Indiana state line, about 60 miles. It is probably contemporaneous with the Cary Moraine, but there is no distinct moraine in the intervening area. South of the Des Plaines Valley it previously was called the Monee Moraine, but that name has had only slight use and is discontinued.

Keeneyville Drift

The Keeneyville Drift, named for Keeneyville, Du Page County, is based on the Keeneyville Moraine (Ekblaw, *in* Suter et al., 1959) (pl. 1). The moraine extends southeast from Keeneyville for about 40 miles and then blends into the back slope of the Wheaton Moraine. The Keeneyville is much less distinct than the West Chicago and Wheaton Moraines. It may be equivalent to the Fox Lake Moraine, with which it was previously correlated (Leighton and Willman, 1953), but it cannot be traced through the intervening 10 miles.

Roselle Drift

The Roselle Drift, named for Roselle, Du Page County, is based on the Roselle Moraine (Ekblaw, *in* Suter et al., 1959) (pl. 1). The moraine is a narrow ridge separating the Keeneyville and Palatine Moraines and has been traced for only 10 miles.

Palatine Drift

The Palatine Drift, named for Palatine, Cook County, is based on the Palatine Moraine (Powers and Ekblaw, 1940) (pl. 1). The moraine is a low, relatively weak morainic ridge about a mile wide and 18 miles long. At both ends the Palatine Drift blends into undifferentiated Valparaiso Drift.

Westmont Drift (New)

The Westmont Drift, named for Westmont, Du Page County, is based on the Westmont Moraine (pl. 1), which extends from north of the Des Plaines Valley to the Indiana state line for about 25 miles. It is one of the more poorly defined moraines in the Valparaiso Morainic System. It previously was correlated with the Palatine Moraine (Leighton and Willman, 1953), but it cannot be traced to the Palatine through the intervening area, and the Palatine could, instead, be equivalent to the Clarendon Moraine.

Clarendon Drift

The Clarendon Drift, named for Clarendon Hills, Du Page County, is based on the Clarendon Moraine (Leighton, *in* Leighton and Willman, 1953) (pl. 1). From 8 miles north of the Des Plaines Valley the moraine has been traced southeastward for 25 miles. At the north end

it blends into the undifferentiated Valparaiso Drift, and at the south end it merges with the back slope of the Westmont Moraine.

Tinley Drift

The Tinley Drift, named for Tinley Park, Cook County, is based on the Tinley Moraine (pl. 1). The moraine originally was called the Tinley Park Moraine (Leighton and Ekblaw, 1932), but the name was later shortened to Tinley (Bretz, 1939). The Tinley is the first moraine back of the Valparaiso Morainic System, and it extends from Wisconsin to Indiana, about 80 miles. It is generally 1 to 3 miles wide. Its front is well defined from the Indiana state line northward to its contact with the undifferentiated Valparaiso Morainic System, about 25 miles south of the Wisconsin state line. The exact position of its front from there to the state line is uncertain in many places (Willman and Lineback, 1970). It has a rough surface comparable to that of the Valparaiso moraines and lacks a distinct crest. Some hills rise 40 to 50 feet above the frontal valley.

Lake Border Drifts

The Lake Border Drifts, named for their position between the Valparaiso Morainic System and Lake Michigan, are based on the Lake Border Morainic System (Leverett, 1897) (pl. 1). The morainic system was differentiated by Leverett into an Outer, or West, Ridge equivalent to the Park Ridge Moraine and probably to part of the Tinley Moraine at ~~the north~~; a Middle Ridge, equivalent to the Deerfield and Blodgett Moraines; and an East Ridge, equivalent to the Highland Park Moraine. The system consists of five morainic ridges a mile or less in width, separated by narrow valleys, and traceable with little difficulty except in the northernmost 10 miles, where there is some overlapping (Willman and Lineback, 1970). The moraines terminate southward where they pass below the Lake Chicago plain, except for the Blue Island Ridge, which has been correlated in part with the Park Ridge Moraine (Bretz, 1939). The Lake Border Drifts are included in the Wadsworth Member of the Wedron Formation and are largely a gray clayey till, generally with a lower content of pebbles and coarser materials than the older drifts. The moraines rise only 20 to 30 feet above the valleys separating them, and they have a relatively smooth surface.

Park Ridge Drift

The Park Ridge Drift, named for Park Ridge, Cook County, based on the Park Ridge Moraine (Bretz, 1939) (pl. 1), is the outermost ridge of the Lake Border System. It is the longest of the Lake Border moraines, extending for 40 miles south from the Wisconsin state line, not including the isolated segment at Blue Island, which is 12 miles farther south.

Deerfield Drift

The Deerfield Drift, named for Deerfield, Lake County, is based on the Deerfield Moraine (Bretz, 1939) (pl. 1). The moraine is about 30 miles long, ending at the south in the Lake Chicago plain. At the north end it appears to be overlapped by the Highland Park Moraine about a mile south of the Wisconsin state line.

Blodgett Drift

The Blodgett Drift, named for Blodgett, Lake County, is based on the Blodgett Moraine (Bretz, 1939) (pl. 1). The moraine is about 20 miles long. It appears to be overlapped by the Highland Park Moraine about 4 miles south of the Wisconsin state line.

Highland Park Drift

The Highland Park Drift, named for Highland Park, Lake County, is based on the Highland Park Moraine (Bretz, 1939) (pl. 1). The moraine extends southward from the Wisconsin state line for about 30 miles, where it is truncated partly by

the shore of Lake Michigan and partly by the beach of the Glenwood stage of Lake Chicago. The Highland Park Moraine has slightly higher relief than the other moraines in the Lake Border Morainic System. Its crest is 50 to 60 feet above the frontal valley in many areas.

Zion City Drift

The Zion City Drift, named for Zion (formerly called Zion City), Lake County, is based on the Zion City Moraine (Ekblaw, *in* Suter et al., 1959). The moraine consists of three small ridges that rise slightly above the surrounding lake plain about 5 miles south of the Wisconsin state line. It is the youngest moraine in Illinois.

Illinoian Drifts

The Illinoian moraines are useful as a basis for morphostratigraphic classification only in local areas, largely in central and western Illinois. The morainic areas south and east from the ridged drift of the Kaskaskia Valley are discontinuous, are not named individually, and have not been correlated in a sequential pattern related to glacial fronts. The two till sheets differentiated in the Vandalia region as rock-stratigraphic units (Jacobs and Lineback, 1969)—the Smithboro and Vandalia Till Members of the Glasford Formation — probably extend over much of the southeastern part of the state, and their extent may eventually be correlated with some of the morainic ridges. For the present, however, morphostratigraphic classification is not useful in that area.

The following drifts are based on Illinoian moraines and may be used locally.

Mendon Drift

The Mendon Drift, named for Mendon, Adams County, is based on the Mendon Moraine (Frye, Willman, and Glass, 1964) (pl. 2). The moraine is a nearly continuous ridge along the outer margin of the Illinoian till plain from the Mississippi Valley near Warsaw, Hancock County, to the Illinois Valley at Pearl, Pike County, about 90 miles. It is largely a smooth-surfaced ridge 1 to 2 miles wide with gentle front and back slopes, but in places it consists of elongate hills with axes parallel to the front. The crest of the moraine is commonly 50 to 100 feet above the Kansan till plain in front. In several areas there is greater relief on the back slope, which suggests that stagnation of the glacier began when the ice was at maximum extent. Morainic hills at the margin of the Illinoian drift in Jersey County probably are the southward continuation of the Mendon Moraine. The Mendon Moraine was used as the basis for an informal rock-stratigraphic unit in northwestern Illinois (Frye et al., 1969), but it is herein replaced by the name Kellerville, and Mendon is retained for the moraine.

Table Grove Drift (New)

The Table Grove Drift, named for Table Grove, Fulton County, is based on the Table Grove Moraine (pl. 2). The moraine was formerly called the Buffalo Hart Moraine (Ekblaw, *in* Wanless, 1957), but the Buffalo Hart Moraine is now restricted to its type area in Sangamon County because the correlation across the large gap of the Illinois Valley is questionable. It seems more likely that, when the Table Grove Moraine was deposited on the upland, the lobe extended down the Illinois Valley, overflowed onto the bluffs, and deposited the moraine that extends from the reentrant near Astoria, Fulton County, to the mouth of the La Moine River on the south side of Schuyler County. This moraine has been correlated with the Jacksonville Moraine (Wanless, 1957) and with the Mendon Moraine (Leighton and Brophy, 1961). The presence of two Illinoian drifts at numerous places in Greene, Macoupin, and Jersey Counties suggests that the Table Grove ice front extended down the Illinois Valley. The morainic ridge near Otterville, Jersey County, may be the extension of the Table Grove Moraine onto the upland east of the Illinois Valley. If, on the other

hand, the Table Grove Moraine correlates with the Jacksonville, the Mendon Drift must contain at least two cycles of drift deposition.

The Table Grove Moraine is essentially continuous northward from Table Grove to near Maquon, southern Knox County. From there it may connect with the Williamsfield Moraine in eastern Knox County, forming a prominent reentrant in the front, as previously mapped (Ekblaw, *in* Flint et al., 1959), or it may connect through Galesburg with the Oneida Moraine in northwestern Knox County. The contrast between the highly oriented drainage pattern of the flat till plain in front of the Table Grove and Oneida Moraines and the unoriented pattern behind the two moraines suggests that they are equivalent. The clay mineral composition of the tills, also, favors the correlation, which in effect relates the Table Grove–Oneida front with the outer margin of the Hulick Till Member of the Glasford Formation.

Oneida Drift (New)

The Oneida Drift, named for Oneida, Knox County, is based on the Oneida Moraine (pl. 2), which is a smooth-surfaced low ridge traceable from Nekoma, Henry County, nearly to Galesburg, Knox County, about 15 miles. It is only 20 to 30 feet high, except for a 75-foot kamic hill (Pilot Knob) at Oneida, and it is distinguished largely by the contrast in topography at its front, as previously noted.

Williamsfield Drift (New)

The Williamsfield Drift, named for Williamsfield, Knox County, is based on the Williamsfield Moraine (pl. 2). The moraine is a weakly morainic ridge only a mile wide that extends south from Williamsfield for about 7 miles. It represents a stand of the ice front during deposition of the Hulick Member of the Glasford Formation. On the south it appears to be truncated by the Oak Hill Moraine. On the north it may connect with isolated patches of morainic topography near Victoria, Galva, and Kewanee.

Oak Hill Drift (New)

The Oak Hill Drift, named for Oak Hill, Peoria County, is based on the Oak Hill Moraine (pl. 2). The moraine is a nearly continuous ridge that extends about 20 miles, from the front of the drift of Wisconsinan age west of Dunlap, Peoria County, southwest to Farmington, Fulton County. The moraine is 40 to 50 feet high and rarely more than a mile wide. It marks the front of the Radnor Till Member of the Glasford Formation. It may be equivalent to a low morainic ridge that extends south from Canton for about 6 miles.

Jacksonville Drift

The Jacksonville Drift, named for Jacksonville, Morgan County, is based on the Jacksonville Moraine (Ekblaw, *in* Ball, 1938b; Ekblaw and Wanless, *in* Wanless, 1957) (pl. 2). The moraine is a discontinuous belt of morainic hills 50 to 100 feet high that extends eastward from the Illinois Valley bluffs through Jacksonville. Farther southeast it may connect with a broad morainic belt from Waverly, Morgan County, to Farmersville, Montgomery County. The segment from Jacksonville to the Illinois Valley bluffs has a gravel core in places, and, as it is nearly at right angles to the front of the Table Grove Moraine, it may be a crevasse deposit. The Jacksonville Moraine was used as the type for the Jacksonville Substage (Leighton and Willman, 1950), but the Jacksonville Moraine does not correlate with a traceable change in the stratigraphic sequence, and these deposits are included in the Monican Substage.

Buffalo Hart Drift

The Buffalo Hart Drift, named for Buffalo Hart, Sangamon County, is based on the Buffalo Hart Moraine (Leverett, 1899a) (pl. 2). The moraine is a broad area of

morainic topography that extends from San Jose, Mason County, to Taylorville, Christian County. It has unusually high and sharp relief for an Illinoian moraine—some hills are 75 to 100 feet high. It has straight ridges oriented at right angles to the front that appear to be crevasse fillings, as well as numerous conical hills that are probably kames. The morainic front with its typical end-moraine topography is particularly well developed near Buffalo Hart. The youthful appearance of the topography has caused many people, starting with Leverett (1899a) to question its Illinoian age. The loess mantle is thick and exposures of a soil on the drift are scarce, but a few exposures and samples from auger holes confirm the presence of the Sangamon Soil on the drift (Johnson, 1964). The Buffalo Hart Drift has the mineral composition of the Radnor Till Member, which suggests its correlation with the Oak Hill Moraine west of the Illinois River, rather than with the Table Grove Moraine, with which it was previously correlated (Wanless, 1957). The Buffalo Hart Moraine was used as the basis for the Buffalo Hart Substage of the Illinoian Stage (Leighton and Willman, 1950). To establish the youngest Illinoian substage in western Illinois, where the stratigraphic relations are better shown, and to avoid the duplicate use of names, Buffalo Hart is retained for the moraine but the youngest Illinoian substage is called Jubileean Substage.

Alluvial Terraces

Alluvial terraces are treated in this report as informal stratigraphic units. The following terraces, all of Woodfordian age (except possibly the Brussels Terrace) have been named in Illinois:

Bath Terrace (Wanless, 1957). Named for Bath, Mason County.

Beardstown Terrace (Wanless, 1957). Named for Beardstown, Cass County.

Brussels Terrace (Rubey, 1952) Named for Brussels, Calhoun County.

Buffalo Rock Terrace (Willman and Payne, 1942). Named for Buffalo Rock, an isolated rock hill in the Illinois Valley, near Ottawa, La Salle County.

Deer Plain Terrace (Rubey, 1952). Named for Deer Plain, Calhoun County.

Festus Terrace (Robertson, 1938). Named for Festus, Missouri.

Havana Terrace (Wanless, 1957). Named for Havana, Mason County.

Indian Creek Terrace (Willman and Payne, 1942). Named for Indian Creek, north of Wedron, La Salle County.

Manito Terrace (Wanless, 1957). Named for Manito, Mason County.

Mankato Terrace (Leighton and Willman, 1949). Named for valley trains of Mankato age.

Ottawa Terrace (Willman and Payne, 1942). Named for Ottawa, La Salle County.

Serena Terrace (Willman and Payne, 1942). Named for Serena, La Salle County.

Sulphur Springs Terrace (Willman and Payne, 1942). Named for Sulphur Springs, near Wedron, La Salle County.

Wedron Terrace (Willman and Payne, 1942). Named for Wedron, La Salle County.

TIME STRATIGRAPHY

According to the A.C.S.N. Code (1961, p. 657), "A time-stratigraphic unit is a subdivision of rocks considered solely as a record of a specific interval of geologic time." The code also states, "Boundaries of time-stratigraphic units at the type locality or area are defined by objective criteria. . . . Geographic extension of a time-stratigraphic unit from its type section or area can be accomplished only as criteria of time equivalence are available, and then only within the limits of accuracy imposed by physical (including isotopic) or paleontologic criteria." The geographic applicability of time-stratigraphic units diminishes with diminishing rank. Therefore, the System and Series categories may be considered as applicable world-wide, the Stage category as continent-wide, and the Substage category as regional.

Quaternary System

The Quaternary System was proposed in 1829 by Desnoyers (Wilmarth, 1925) to include all post-Tertiary time as expressed by the deposits in the basin of the Seine River in France. The definition is loose and is based on the placement of the end of the Tertiary System, but, as this position in time coincides with the beginning of the Pleistocene Series, it presents no practical problem to modern classification. In Illinois classification, the Quaternary System is equivalent to its one series, the Pleistocene.

Pleistocene Series

The term Pleistocene was introduced by Lyell in 1839 as a replacement for Newer Pliocene (Lyell, 1833) to apply to the marine strata in the Mediterranean region in which more than 70 percent of the species are species still living. In the light of present knowledge, such a definition would include much of the time now assigned to the late Tertiary. In 1846 Forbes used the word Pleistocene to apply to the "glacial epoch," thus giving a climatic implication—a redefinition to which Lyell agreed in 1873. A definition based on climatic change as evidenced by continental glaciation is generally used in North America, as was indicated by Wilmarth in 1925 (p. 49): " . . . Pleistocene epoch includes the deposits of the Great Ice Age, as it is popularly known, and contemporaneous marine, fluviatile, lacustrine, and volcanic rocks . . . " Such a statement, however, does not diminish the need for a type section, and debate concerning the definition of an appropriate type section in the Mediterranean region has not subsided. In more recent years, Gignoux (1943) proposed the top of the marine Calabrian of southern Italy as the lower boundary, but Movius (1949) and Migliorini (1950) proposed the base of the Calabrian and its presumed nonmarine equivalent, the Villafranchian, as the base of the Pleistocene. At the 18th International Geological Congress in Great Britain in 1948, a commission was appointed to study this problem, and a report was made at the 19th International Geological Congress in Algiers in 1952. Although the commission's report generally agreed with placement of the boundary at the base of the Calabrian or Villafranchian, the debate and disagreement continue. Correlation of the marine sequence of the Mediterranean region with the marine sequence of North America has not been firmly established, but the vertebrate fauna of the Villafranchian has been correlated with the Blancan fauna of the western United States, which in turn has been correlated with the Nebraskan (McGrew, 1944; Frye, Swineford, and Leonard, 1948).

In interior North America, placement of the basal contact of the Pleistocene is a practical problem mainly in the Great Plains region, where early Pleistocene deposits rest unconformably on late Tertiary deposits (Frye and Leonard, 1952). In Illinois and adjacent states, the earliest ap-

pearance of deposits genetically related to the first episode of continental glaciation is considered as marking the base of the Pleistocene. Nonglacial deposits that can be correlated with these are, of course, also classed within the Pleistocene.

In Illinois, reference sections showing the base of the Pleistocene are not of great significance because the lowermost stages are based on type localities in Iowa, Nebraska, and Kansas. Early Pleistocene deposits (Nebraskan Stage) overlying bedrock are known from several localities in central western Illinois (e.g., Enion and Zion Church Sections, table 6; Big Creek and Otter Creek Sections, table 7; Banner West Section (SE SE SE Sec. 3, T. 6 N., R. 5 E., Fulton County). Some deposits of Grover Gravel and Mounds Gravel that may be of Nebraskan age and rest on bedrock may represent the base of the Pleistocene, but such correlations are entirely too tenuous to allow use of the localities in which the gravels occur as reference sections. The base of the Pleistocene Series, like that of the Quaternary System, is based on successions and definitions established far from Illinois and they are used here by correlation.

Nebraskan Stage

The name Nebraskan was proposed by Shimek (1909) for the lowermost till at the Afton Junction–Thayer exposures in Union County, Iowa. This lowermost till had earlier been called Kansan by Chamberlin (1894, 1895) and by Calvin (1896), on the basis of its supposed extension into northeastern Kansas. However, Bain in 1897 (p. 464) stated: "A preliminary examination as far south as Kansas City seemed to show that the older drift did not come to the surface, and accordingly the upper drift at Afton Junction is presumably the surface drift of eastern Kansas, though the matter has not been fully studied." As a result of Bain's work, Kansan was transferred to the upper drift in the Union County, Iowa, exposures, and the name Albertan, or sub-Aftonian, was assigned to the lower one (Calvin, 1897). The name Nebraskan was proposed for the lower till in 1909 by Shimek on the basis of its supposed extension into Nebraska, and this term has enjoyed general acceptance in the Missouri River Basin region.

The type locality is in the glaciated part of eastern Nebraska and consists of glacial tills and associated outwash. The top of the Nebraskan Stage in the type area is the top of the Afton Soil. Reed and Dreeszen (1965, p. 23) stated that the oldest known till in Nebraska is the Elk Creek Till overlying the pro-glacial David City sand and gravel (Lugn, 1935), which rests on Pennsylvanian limestones and shales. Therefore, the base of the David City sand and gravel in eastern Nebraska is the type for the base of the Nebraskan Stage, as well as for the base of the Pleistocene Series as it is used in the central United States.

In Illinois, exposures of till of Nebraskan age, or other deposits definitely correlated with the Nebraskan Stage, are exceedingly rare. Such exposures are limited to the central western part of the state (e.g., Enion, Zion Church Sections, table 6).

Aftonian Stage

Chamberlin proposed the term Aftonian in 1894 for Afton Junction, midway between Afton and Thayer in Union County, Iowa, where deposits he thought represented an interglacial stage were exposed in a gravel pit. He included within his Aftonian the "forest bed" deposits and outwash sand and gravel earlier described by McGee (1890). During subsequent years, usage has transferred the standard of comparison to the accretion-gley deposits on till of Nebraskan age in southern Iowa (the Nebraskan gumbotil of Kay and Apfel, 1929) and to the deeply developed insitu Afton Soil profile developed in till of Nebraskan age (e.g., Iowa Point Section, Doniphan County, Kansas; Frye and Leonard, 1952). Although there is reasonable doubt concerning the age of the gravels exposed at Afton Junction, as previously

noted, the name Aftonian is retained because of its long accepted use. However, the type for the Aftonian should be considered the Afton Soil. As a reference section for Illinois, the deeply developed Afton Soil at the Zion Church Section (table 6) meets the necessary requirements as a paratype.

Kansan Stage

The name Kansan, although first proposed by Chamberlin in 1894, was assigned its present position in 1897 (Calvin, 1897) after Bain (1897) had demonstrated the correlation of the upper till in the Afton Junction area of Union County, Iowa, with the surface drift of northeastern Kansas. Although the Afton Junction gravel pit must be recognized as the original type locality, the fact that the name was transposed from that locality after the till had been traced to northeast Kansas, for which the stage was named, clearly implies that the actual type is in that part of Kansas. Acting on that presumption, Frye and Leonard in 1952 proposed three reference sections in Atchison and Doniphan Counties, Kansas, for the Kansas till. As they also included within the Kansan Stage the Atchison Formation below the till and the Meade Formation that is stratigraphically equivalent to at least part of the till and locally overlies it, a type sequence for the Kansan Stage could appropriately be considered as extending from the base of the type Atchison Formation (Atchison County, Kansas) upward through the Kansas till to the top of the Meade Formation. The stage is terminated at the top by the top of the Yarmouth Soil.

Many suitable reference sections for the Kansan Stage have been described in central western Illinois. Included with this report are the Enion, Tindall School, and Zion Church Sections (table 6). Previously published sections include, among others, Big Creek and Big Sister Creek in Fulton County, Mill Creek in Adams County, Petersburg Dam, Rushville (4.5 W), and Taylorville Dam Sections (table 7).

Yarmouthian Stage

The Yarmouthian Stage is based on the Yarmouth Soil, described by Leverett (1898c) from its occurrence in a well section near Yarmouth, Des Moines County, Iowa. It was described as the interval of weathering and organic accumulation separating the Kansan and Illinoian glacial deposits. The adjectival ending was added to Yarmouth by Frye, Swineford, and Leonard (1948) to distinguish the stage from the soil.

The original type section of the Yarmouth has not been available for study for many years. However, in Lee County, Iowa, adjacent to Des Moines County on the south, two sections of Yarmouth Soil have been described in detail (Willman, Glass, and Frye, 1966). The Fort Madison Section contains 13 feet of accretion-gley resting on till of Kansan age and overlain by till from the earliest episode of Illinoian glaciation. This section could, therefore, serve as a paratype for the Yarmouthian Stage. In this section the top of the Yarmouth Soil defines the top of the stage. The Donnellson Section, also in Lee County, Iowa, contains an in-situ Yarmouth Soil developed in Kansan till and serves as a reference section wherein only a soil-stratigraphic unit represents the stage. As Des Moines and Lee Counties, Iowa, are adjacent to Illinois on the west, correlations with these localities are readily made.

In the stratigraphic sections in this report, the Yarmouthian Stage is represented by the Lierle Clay Member (accretion-gley) of the Banner Formation at the Zion Church Section (table 6), and by in-situ soil profiles in the Banner Formation at the Enion and Tindall School Sections (table 6) and in the Mounds Gravel in the Cache and Gale Sections (table 6). Other published sections that describe the Yarmouthian in Illinois include the Dixon Creek East, Lierle Creek, Little Menominee East, Seehorn, and Taylorville Dam Sections (table 7).

Illinoian Stage

Leverett (*in* Chamberlin, 1896) named the Illinois till sheet and introduced

(1899a) the term Illinoian Stage. He included within it all the deposits between the Yarmouthian and Sangamonian Stages (of present usage) and named it for the Illinois Glacial Lobe. Leverett considered the extent of the lobe to be the type region and did not specify a particular type section. As the stratigraphic code (A.C. S.N., 1961) requires that stages be defined from type sections, it is desirable to specify a paratype section within the type region. The Tindall School Section (table 6) is an appropriate paratype section for the Illinoian Stage. There the Illinoian deposits overlie truncated Yarmouth Soil developed in till of the Banner Formation of Kansan age; typical deposits of all three substages are present; and they are terminated at the top by an in-situ Sangamon Soil developed in till, overlain by the Markham Silt Member of the Roxana Silt of earliest Wisconsinan age.

Liman Substage

The Liman Substage of the Illinoian Stage was named and described by Frye, Willman, and Glass (1964, p. 27). It is named for Lima Township, Adams County, and described from the Pryor School Section, NE NE SE Sec. 11, T. 2 N., R. 8 W. At the type section the Liman Substage is represented by the Petersburg Silt and the Kellerville Till Member of the Glasford Formation. It rests on truncated Yarmouth Soil developed in the Banner Formation of Kansan age, and is terminated at the top by a truncated soil overlain by Wisconsinan loess. Other geologic sections included with this report that may be considered typical of the Liman Substage are Cottonwood School, Enion, New Salem Northeast, Pleasant Grove School, and Tindall School (table 6). At the New Salem Northeast Section, the top of the well developed Pike Soil in Kellerville Till defines the top of the substage.

Monican Substage (New)

The Monican Substage of the Illinoian is herein named for the village of Monica, Peoria County, and is based on the Jubilee College Section described in table 6. It is the substage above the Liman and below the Jubileean. The Monican replaces, in part, the Jacksonville or Jacksonvillian Substage of previous literature.

In the type area, the Hulick Till Member of the Glasford Formation rests on shale of Pennsylvanian age. The till is overlain at an erosional contact by outwash sand, silt, and gravel that is partly leached and oxidized in its upper part. The top of the Monican Substage is defined as the top of this unnamed soil in outwash of the Toulon Member of the Glasford Formation. The type sequence of the next younger substage, the Jubileean, immediately overlies this minor soil.

Jubileean Substage (New)

The Jubileean Substage of the Illinoian is herein named for Jubilee College State Park, Peoria County, and is based on the Jubilee College Section described in table 6. It is the uppermost substage of the Illinoian Stage. The Jubileean replaces, in part, the Buffalo Hart or Buffalohartian Substage of earlier literature.

In the type section, silt and fine sand that is calcareous, gray, and massive overlies the soil at the top of the Monican Substage. This silt and sand is the upper part of the Toulon Member of the Glasford Formation and is overlain by the Radnor Till Member. A strongly developed in-situ profile of Sangamon Soil occurs in the top of the Radnor Till. The Sangamon Soil is overlain by Roxana Silt of Altonian age.

Sangamonian Stage

The name Sangamon interglacial stage was proposed by Leverett (1898b, p. 171-181) from Sangamon County. The interglacial stage was based on a soil that occurred above the tills of Illinoian age and was overlain by loesses of Wisconsinan age. Leverett designated the type locality as northwestern Sangamon County, and pointed out that the presence of the soil had been noted by Worthen (1873b). The ad-

jectival ending, to designate use as a time-stratigraphic unit and to differentiate the stage from the soil, was introduced by Frye and Leonard in 1952.

In view of the fact that the original well section, described by Worthen and quoted by Leverett, was not re-examined by Leverett or any subsequent worker, it seems desirable to designate paratype sections for the time-stratigraphic unit as well as for the soil-stratigraphic unit.

The Rochester Section (table 6), in eastern Sangamon County, is representative of the accretion-gley largely of Sangamonian age, the Berry Clay Member of the Glasford Formation. It occurs above glacial till of Illinoian age and is overlain by loess of Wisconsinan age. At the Chapin Section (table 6) in Morgan County, adjacent to Sangamon County on the west, the Sangamon Soil is an in-situ profile developed in till and is overlain by the oldest unit of Wisconsinan loess. The Sangamon Soil at the Chapin Section is designated as a paratype for the stage.

Wisconsinan Stage

The term East-Wisconsin Formation was proposed by Chamberlin in 1894. In 1895 he changed the name to Wisconsin Formation. Leverett (1899a) gave a comprehensive description of the Wisconsin drift sheets of Illinois and called them the Wisconsin stage. The initial description was based largely on patterns of end moraines, and it clearly included much less than is now placed within the stage (Frye et al., 1968). The evolutionary history of the Wisconsinan Stage is shown diagrammatically in figure 13, and its spatial relations to radiocarbon dates in figure 14. Table 1 lists the stratigraphically significant radiocarbon dates from Illinois.

The adjectival ending was first used by Frye, Swineford, and Leonard in 1948 in Kansas to identify the stage distinctively as a time-stratigraphic unit, and the adjectival ending was introduced into Illinois by Frye and Willman in 1960.

The Wisconsinan Stage in the Lake Michigan Lobe was redefined by Frye and Willman in 1960, and was defined in more detail and slightly modified in 1968 by Frye et al. That definition is accepted for this report. The base of the Wisconsinan Stage was defined as the base of the Roxana Silt on the A-horizon of the Sangamon Soil. Although no one section was designated as the type for the stage, the basal contact was described as occurring in the Cottonwood School Section (table 6) where the Markham Silt Member of the Roxana Silt rests on the A-zone of the Sangamon Soil developed in till of the Hulick Till Member of the Glasford Formation. The Cottonwood School Section is suggested as a paratype section for the Wisconsinan Stage where it is represented by a sequence of loesses. The upper boundary of the Wisconsinan Stage was defined as the contact between the Cochrane till and the post-Cochrane deposits in Ontario, Canada (Frye et al., 1968, p. E12)

Altonian Substage

The Altonian Substage was named (Frye and Willman, 1960; Frye et al., 1968) for Alton, Madison County, and was based on the sequence of Roxana Silt exposed in the Alton Quarry Section (Leonard and Frye, 1960). It is the lowest and oldest subdivision of the Wisconsinan Stage. In the type region, reference sections include the Reliance Whiting Quarry Section (table 7) and the Pleasant Grove School Section (table 6). The base of the Altonian Substage coincides with the base of the Wisconsinan Stage and is drawn at the contact of the Markham Silt Member of the Roxana Silt on the A-zone of the Sangamon Soil developed in deposits of Illinoian age. Although finite radiocarbon dates have not as yet been obtained from the base of the Altonian Substage, reasonable extrapolations suggest 75,000 B.P. as a probable date. The top of the Altonian, in contrast, is extensively dated by the radiocarbon method and falls at approximately 28,000 B.P. Stratigraphically, this boundary is placed at the contact of the Robein Silt

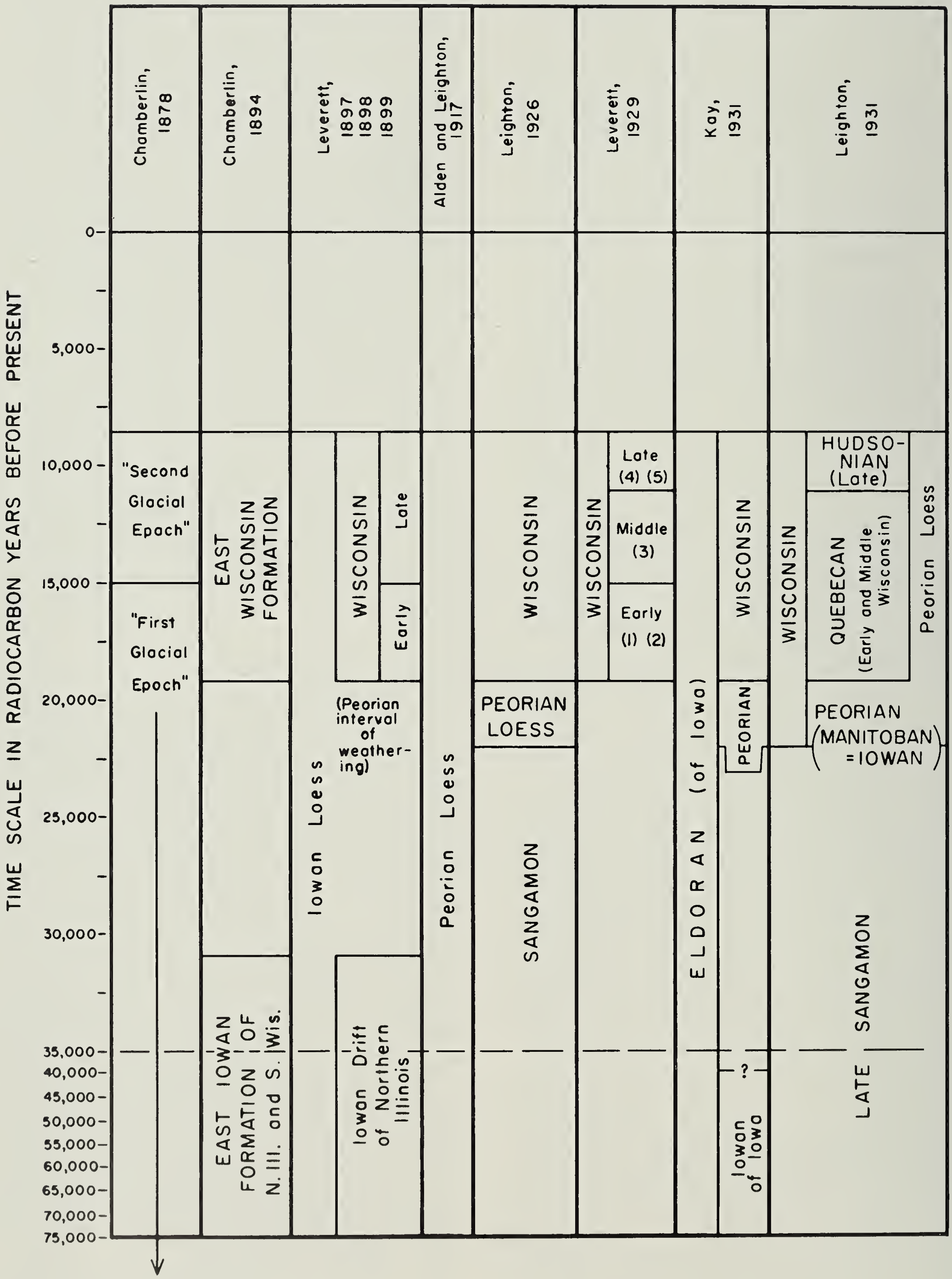
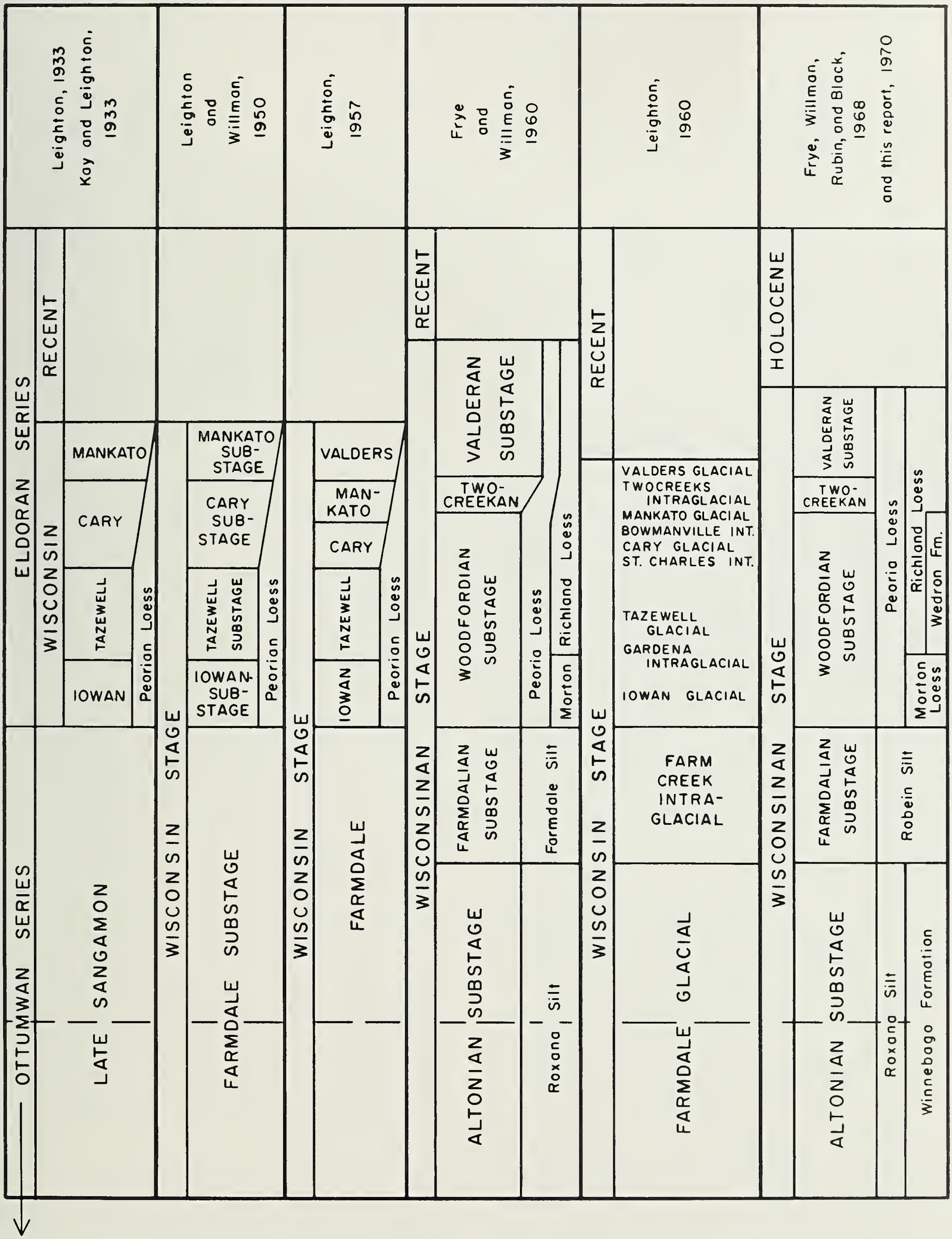


Fig. 13 — Major steps in development of the stratigraphic classification



of the Wisconsinan deposits of Illinois (after Frye and Willman, 1963).

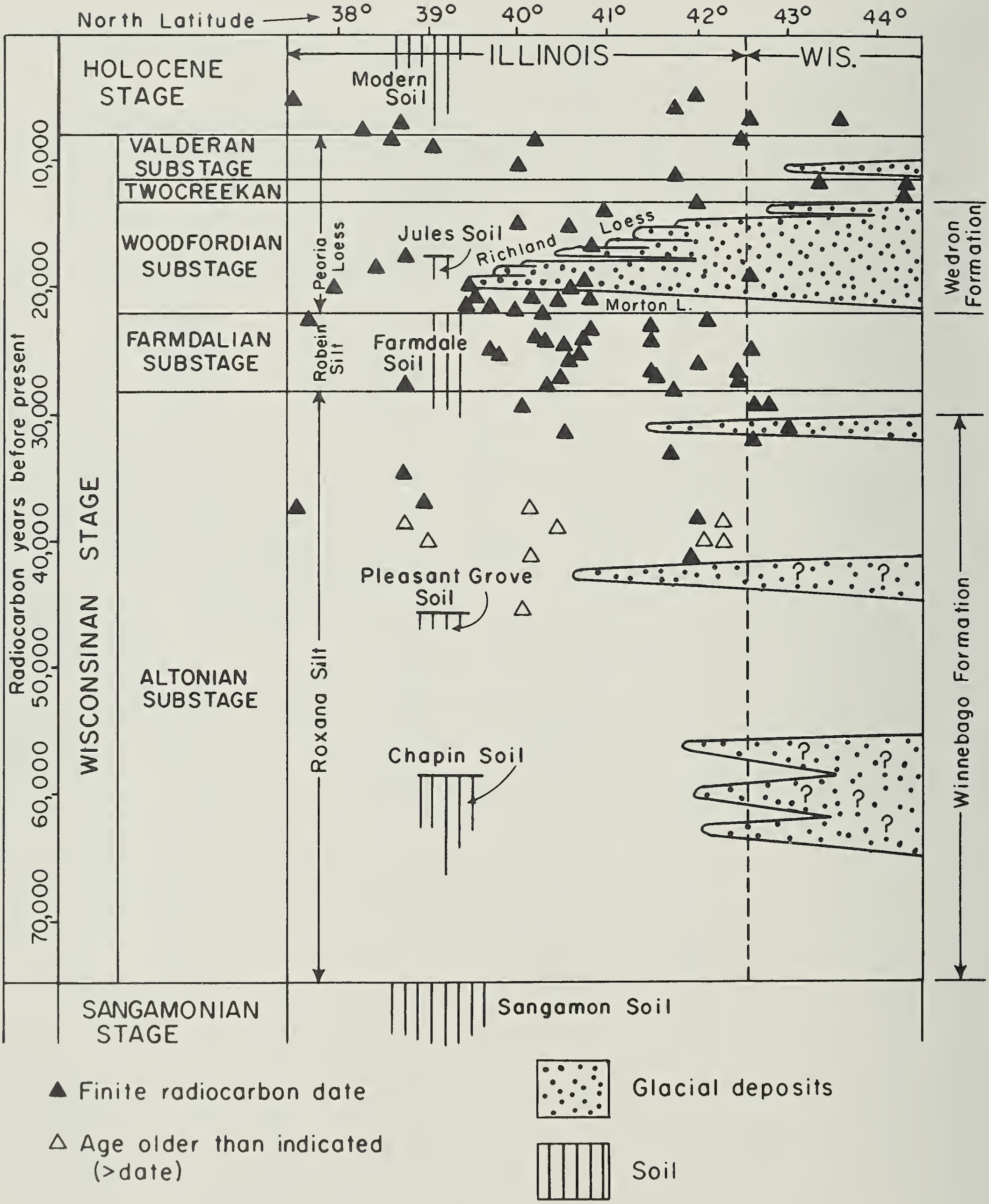


Fig. 14 — Time-space diagram showing glacial deposits, soils, and stratigraphically significant radiocarbon dates in the Wisconsinan and Holocene Stages in Illinois.

on the Roxana Silt, or, in the absence of the Robein Silt, at the top of the Farmdale Soil developed in the Roxana Silt or in equivalent glacial deposits (Winnebago Formation) in northern Illinois. By the extrapolated radiocarbon time scale, the Altonian Substage occupies more than half the time span of the Wisconsinan Stage (figs. 13 and 14). In the loess sequence, the Altonian Substage contains all of the Roxana Silt, and in the glacial sequence it contains all of the Winnebago Formation. The molluscan fauna of the late Altonian has been described by Leonard and Frye (1960), and the radiocarbon dates are listed in table 1 and located graphically in figure 14.

Farmdalian Substage

The Farmdalian Substage is named for Farmdale, Tazewell County. The term Farmdale Substage was first proposed by Leighton and Willman in 1950. The term Farmdalian Substage was first proposed by Frye and Willman in 1960 and was defined in detail (Frye et al.) in 1968.

The type section is the Farm Creek Section (table 6), which was the original type section for the Farmdale and still is the type for the Farmdale Soil and the Robein Silt. The section was described by Leverett (1899a, p. 128) and by Leighton (1925a, 1926b). The Farm Creek Railroad Cut Section nearby also has been described (Leonard and Frye, 1960; Frye and Willman, 1960), and it is that section that serves as the type for the Morton Loess. The Robein Silt, on which the Farmdalian Stage is based, rests on the Roxana Silt and is overlain by the Morton Loess. The molluscan fauna of the Farmdalian has been described by Leonard and Frye (1960).

The Farmdalian is more thoroughly covered, both stratigraphically and geographically, by radiocarbon dates than any other substage in Illinois. The several dozen dates from the Robein Silt, from the Roxana Silt and Winnebago Formation below, and from the overlying Morton Loess and Wedron Formation, are listed in table 1, and their position is shown graphically in figure 14. The time span of the substage in the type section is from approximately 28,000 B.P. to approximately 22,000 B.P. radiocarbon years. The history of the usage of the terms Farmdale and Farmdalian is shown in figure 13.

Woodfordian Substage

The Woodfordian Substage was named for Woodford County (Frye and Willman, 1960; Frye et al., 1968), where deposits of this age are exposed over nearly the entire county. It is based on the sequence of deposits above the contact of the Morton Loess on the Robein Silt, as it occurs in the type area of those formations, upward to the base of the Two Creeks deposits typically exposed in east-central Wisconsin. Described stratigraphic sections with this report that may be considered partial paratypes for the substage include the Farm Creek, Malden South, and Wedron Sections (table 6). Its upper boundary is the contact of till with waterlaid silt, clay, sand, and the "forest bed" at Two Creeks, Wisconsin, described by Thwaites and Bertrand (1957, p. 856). In the loess sequence of Illinois, the exposures of Peoria Loess in the Cottonwood School (table 6) and Frederick South (table 7) Sections are paratypes for the Woodfordian. The molluscan fauna of the Woodfordian, largely collected from the Peoria Loess, has been described (Leonard and Frye, 1960).

Radiocarbon dates from the mid-part of the Woodfordian are few, but many dates have been determined in association with its basal contact (table 1, figure 14) that serve to place its base at approximately 22,000 radiocarbon years B.P. Many radiocarbon dates also have been obtained from the Two Creeks deposits of Wisconsin (Black and Rubin, 1968; Broecker and Farrand, 1963) that indicate a probable radiocarbon age of 12,500 B.P. for the top of the substage.

The history of the terminology of the Woodfordian is shown graphically in figure 13. In the earlier Illinois literature, Hud-

sonian, Quebecan, Manitoban (Leighton, 1931), Iowan, Tazewell, Cary (Leighton, 1933), and the redefined Mankato (Leighton, 1957a) all fall within the Woodfordian Substage. Other rejected time terms that fall within the Woodfordian include Bowmanville intraglacial, St. Charles intraglacial, and Gardena intraglacial (Leighton, 1960).

Twocreekan Substage

The Twocreekan Substage was named for Two Creeks, Manitowoc County, Wisconsin (Frye and Willman, 1960; Frye et al., 1968). It was defined on the basis of the description of the classic Two Creeks deposits 2 miles east of Two Creeks in the bluff of Lake Michigan (Secs. 11 and 12, T. 21 N., R. 25 E.) by Thwaites and Bertrand (1957, p. 856), who stated that more than 10 feet of lake clay overlies a till and is overlain locally by silt and sand, on which occurs the well known forest bed. Many radiocarbon dates have been determined from the forest bed at the top of the Two Creeks deposits (Black and Rubin, 1968; Broecker and Farrand, 1963), and a reasonable extrapolation gives a time span for the Twocreekan from 12,500 to 11,000 radiocarbon years B.P.

Deposits of the Twocreekan Substage cannot generally be differentiated in the stratigraphic sequence in Illinois.

Valderan Substage

The Valderan Substage was named for Valders, Manitowoc County, Wisconsin (Frye and Willman, 1960; Frye et al., 1968). The type locality is the exposures in the quarry at Valders, described by Thwaites (1943) and by Thwaites and Bertrand (1957). A Valders substage was proposed by Thwaites (1941, 1943) and was modified by Leighton (1957a, 1960). As defined by Frye and others in 1968, the base of the substage is the contact of Valders till on the Two Creeks forest bed, and the top is the contact at the top of Cochrane till below post-Cochrane deposits in the James Bay Lowland of Ontario, Canada (Hughes, 1956, p. 5; 1965). The apparent time span of the Valderan Substage is from 11,000 to 7,000 radiocarbon years B.P., athough the radiocarbon dating of its upper contact is only an approximation.

In Illinois, suitable reference sections of the Valderan Substage have not been described. The substage is represented in the deposits of Lake Chicago, in the valley-train deposits of the Mississippi Valley, and by climatically induced deposits of gravel, sand, and silt on the tills of the Wedron Formation and in some minor valleys. The gravel, sand, and silt deposits have been radiocarbon dated (table 1) and they contain vertebrate fossil remains locally.

Holocene Stage

The Holocene Stage, although based on a term and a concept that developed more than a century ago, has never been properly defined as a time-stratigraphic unit. It has been accepted as a replacement for Recent by the U.S. Geological Survey (Cohee, 1968) but without formal stratigraphic definition. For formal use in Illinois we propose that Holocene Stage replace the term Recent Stage as the youngest time-stratigraphic subdivision of the Pleistocene Series. In that sense it may be defined as embracing all deposits younger than the top of the Wisconsinan Stage, as presently defined. In radiocarbon years the Holocene extends from approximately 7,000 B.P. to the present.

GLOSSARY

The glossary is divided into three sections. Section A contains rejected stratigraphic names, section B lists names of glacial lakes, lake stages, and shorelines, and section C gives names of peneplains, straths, and erosion surfaces.

A. REJECTED STRATIGRAPHIC NAMES

Albertan Drift Sheet

Dawson and McConnell, 1895. Named for province of Alberta, Canada. Earliest glaciation. Accepted by Chamberlin (1896) for oldest of two drift sheets differentiated by McGee in eastern Iowa (Leverett, 1897, 1899a; Calvin, 1897). Replaced by Kansan and Nebraskan Stages.

Arlington Heights Moraine

Leighton and Ekblaw, 1932. Named for Arlington Heights, Cook County. Woodfordian. Replaced by Tinley Moraine.

Ashkum-Bryce Moraine

Leighton and Brophy, 1961. Named for towns in Iroquois County. Woodfordian. Replaced by Gilman Moraine.

Bentley Formation

Fisk, 1938. Named for Bentley, Grant Parish, Louisiana. Equivalent to the Smithland surface gravel (Leighton and Willman, 1949). Pliocene-Pleistocene. Included in the Mounds Formation.

Bowmanville Substage

Baker, 1920b. Named for Bowmanville, Cook County. Low-water stage of Lake Chicago. Equated with Two Creeks peat by Bretz (1955). Substage between Cary and Mankato (Leighton, 1960). Not accepted as definite evidence of low-water stage (Hough, 1958). Woodfordian. Deposits included in Equality Formation.

Brussels Formation

Rubey, 1952. Named for Brussels, Calhoun County. Deposits in Brussels Terrace. See also Lake Brussels. Equivalent to Cuivre Terrace deposits (Robertson, 1938). Related to Illinoian ice blocking Mississippi River at St. Louis (Rubey, 1952; Leighton and Brophy, 1961). Because there is no evidence of Sangamon Soil and Roxana Silt on the sediments, the Illinoian age is questionable and the deposits are tentatively assigned to the Equality Formation.

Buffalo Hart Substage

Leighton and Willman, 1950. Named for Buffalo Hart, Sangamon County. Based on the Buffalo Hart Moraine. Illinoian. Replaced by Jubileean Substage. Name retained for the moraine.

Cary Substage

Leighton, 1933. Named for Cary, McHenry County. Equated with "Middle Wisconsin." Interval from the base of the Minooka Drift in Illinois to the base of the Mankato-age drift in eastern Wisconsin, which then was the base of the Valders Drift and the top of the Two Creeks deposits. Restricted (Leighton, 1957a) by correlating type Mankato (Minnesota) with deposits older than Two Creeks, including Port Huron (Michigan). Included in Woodfordian (Frye and Willman, 1960). Name retained for Cary Moraine (see Monee Moraine).

Centralian Series, Epoch

Kay, 1931. Named for Centralia, Marion County. Includes Illinoian and Sangamonian. Use in Illinois discontinued in 1952.

Coal Hollow Moraine

Cady, 1919. Named for village of Coal Hollow, Bureau County. Included in Arlington Moraine.

Columbia Group

McGee, 1886a, 1886b. Named for District of Columbia. Used in Illinois by Hershey (1895) as Columbia Formation and divided into three members—Florence Gravel, Valley Loess Member, and Upland Loess Member. Included in Equality Formation, Roxana Silt, and Peoria Loess.

Cropsey Morainic System

Named for Cropsey, McLean County. Called Cropsey Ridge (Leverett, 1899a), Cropsey System (Leighton and Ekblaw, 1932). Restricted to Cropsey Moraine (Leighton and Brophy, 1961). Woodfordian. Replaced by several named moraines (see Minonk Drift under Morphostratigraphy).

Cuivre Terrace

Robertson, 1938. Named for the Cuivre River, tributary of the Mississippi River north of St. Charles, Missouri. Equivalent to Brussels (see above).

Eldoran Series, Epoch

Kay, 1931. Named for Eldora, Hardin County, Iowa. Includes Iowan, Peorian, and Wisconsin Stages. Redefined (Kay and Leighton, 1933) to consist of Wisconsin and Recent Stages, the Wisconsin consisting of Iowan, Tazewell, Cary, and Mankato Substages. Use in Illinois discontinued in 1952.

Farm Creek Substage

Leighton, 1960. Named for Farm Creek, Tazewell County. Included in Farmdalian Substage of present usage.

Farmdale Loess, Substage

Leighton, *in* Wascher, Humbert, and Cady, 1948; Leighton and Willman, 1949, 1950. Named for Farmdale, Tazewell County. Previously called Late Sangamon Loess. Type section NE SW SE Sec. 30, T. 26 N., R. 3 W., Tazewell County. Farmdale Loess subdivided (Frye and Willman, 1960) into Farmdale Silt (at top) and Roxana Silt. Farmdale Silt replaced by Robein Silt. Farmdale Substage replaced by Farmdalian Substage (at top) and Altonian Substage (Frye and Willman, 1960). Wisconsinan. Farmdale retained for Farmdale Soil.

Florence Gravel Member

Hershey, 1895. Named for village of Florence or Florence Township, Stephenson County. Equated with Port Hudson Member of Columbia Formation in Mississippi Embayment. Exposed in banks of Yellow and Crane Creeks, a few miles west and south of Freeport, where it can be examined only at low-water level. Probably basal part of deposits in Lake Silveria (Hershey, 1896d). Altonian. Included in Equality Formation.

Florencia Formation

Hershey, 1897b. Modification of Florence (see above).

Gardena Substage

Leighton, 1960. Named for Gardena, Tazewell County. Type section 3 miles north of Gardena is same as Farmdale type section. Assumed intraglacial interval between Iowan and Tazewell Substages. Equivalent to contact between Morton Loess and Shelbyville Drift.

Grandian Epoch, Series

Kay, 1931. Named for Grand River Valley of southwestern Iowa. Includes Nebraskan and Aftonian. Use in Illinois discontinued in 1952.

Hennepin Gravel

Cady, 1919. Named for Hennepin, Putnam County. Name applied to gravel in the terrace at Hennepin. Included in the Henry Formation.

Hudsonian Substage

Leighton, 1931. Named for Hudson Bay, Canada, around which the ice fields were approximately equally developed. Equated with Late Wisconsin (Port Huron, Des Moines Lobe, and younger). Discontinued by Kay and Leighton (1933).

Iowan Loess, Stage, Substage

Chamberlin, 1894, named East Iowan; dropped " East" in 1896. Named for the

state of Iowa. Applied to the younger of the two tills of McGee (1890). Defended by Calvin (1899), Alden and Leighton (1917), Kay and Graham (1943), Leighton (1958a, 1960), and Leighton and Brophy (1966). The existence of the Iowan as a separate glaciation was questioned by Leverett (1909, 1929c, 1929d). Ruhe, Rubin, and Scholtes (1957) suggested it was pre-Farmdale. Ruhe and Scholtes (1959) and Ruhe et al. (1968) rejected the Iowan, interpreting it as eroded Kansan. Leighton (1931) made the Iowan a substage of the Wisconsin. This usage was rejected for Illinois by Frye and Willman (1960). Leverett (1898a) applied the name Iowan Loess to the loess both beneath and outside the Wisconsin till. Leighton (1931) called both Peorian Loess, later (1933) restricted Peoria to the loess outside the Wisconsin till and applied Iowan to the loess beneath the till, and still later (1965) used Iowan for part of the loess previously called Peorian. Frye and Willman (1960) replaced Iowan Loess with Morton Loess.

Jacksonville Substage

Leighton and Willman, 1950. Named for Jacksonville, Morgan County, and based on the Jacksonville Moraine. Illinoian. Replaced by Monican Substage. Name retained for the moraine.

Joliet Conglomerate

Goldthwait, 1909. Named for Joliet, Will County. Cemented gravel overlain by Valparaiso Drift. Called Joliet Outwash Plain by Fisher (1925). Included in Wedron Formation.

Kempton Moraine

Leighton and Brophy, 1961. Named for Kempton, Ford County. Woodfordian. Not differentiated from Ransom Moraine.

Kishwaukee Moraine

Leighton and Ekblaw, 1932. Named for Kishwaukee River in McHenry County. Later replaced by Marseilles. Woodfordian. Now differentiated into the Huntley and Barlina Moraines.

Lafayette Gravel

Hilgard, 1891. Named for Lafayette County, Mississippi. Replaced the descriptive term Orange Sand (Safford, 1856). Replaced by Grover Gravel and Mounds Gravel.

Late Sangamon Loess

Leighton, 1926b. Named for assumed age. Replaced by Farmdale. Now equivalent to Robein and Roxana Silts.

Manitoban Substage

Leighton, 1931. Named for province of Manitoba, Canada. Center of radiation of Iowan glacier. Discontinued by Kay and Leighton (1933).

Mankato Substage

Leighton, 1933. Named for Mankato, Minnesota. Originally defined for glacial substage younger than Two Creeks deposits. In Lake Michigan Lobe renamed Valders by Thwaites (1943). Mankato redefined to lie below the Two Creeks by Leighton (1957a). Included in Woodfordian Substage by Frye and Willman (1960). Upper Mankato and Lower Mankato Terraces in Mississippi Valley named for assumed age (Leighton and Willman, 1949, 1950).

Mendon Till

Frye, Willman, and Glass, 1964. Named for Mendon, Adams County. Replaced Payson Till (Leighton and Willman, 1950). Used in northwestern Illinois (Frye et al., 1969). Replaced by Kellerville Till Member. Name retained for Mendon Moraine.

Monee Moraine

Powers and Ekblaw, 1940. Named for Monee, Will County. Proposed to replace Cary, which had been used for a substage. Cary reinstated for the moraine in type area (Ekblaw, *in* Suter et al., 1959). Monee replaced by Wheaton farther south.

Montgomery Formation

Fisk, 1938. Named for Montgomery, Grant Parish, Louisiana. Equivalent to the Havana Strath deposits (Leighton and

Willman, 1949, 1950). Pliocene-Pleistocene. Included in the Mounds Formation.

Ottumwan Epoch, Series

Kay, 1931. Named for Ottumwa, Wapello County, Iowa. Includes Yarmouth and Kansan. Use in Illinois discontinued in 1952.

Payson Substage

Leighton and Willman, 1950. Named for Payson, Adams County. Earliest Illinoian substage. Replaced by Liman (Frye, Willman, and Glass, 1964).

Peorian Loess, Substage

Leverett, 1898a. Named for Peoria, Peoria County. Interglacial stage between Iowan and Wisconsin glaciations. Replaced Toronto, used by Chamberlin (1895), because of uncertain correlation to Illinois. Use for interglacial interval discontinued by Leighton (1931). Peorian Loess (Alden and Leighton, 1917) changed to Peoria Loess (Frye and Willman, 1960).

Pilot Moraine

Leighton and Brophy, 1961. Named for Pilot Grove, Vermilion County. Replaced by Newtown Moraine.

Prairie Formation

Fisk, 1938. Named for prairies near Aloha, Grant Parish, Louisiana. Equivalent to Mankato Terrace (Leighton and Willman, 1949, 1950), Festus Terrace (Robertson, 1938), Deer Plain Terrace (Rubey, 1952), Bath Terrace (Wanless, 1957), Ottawa Terrace (Willman and Payne, 1942). Woodfordian.

Quebecan Substage

Leighton, 1931. Named for province of Quebec, Canada, the source region of the early and middle Wisconsin glaciers. Discontinued by Kay and Leighton (1933).

Recent Stage

Lyell, 1833. Redefined by Forbes (1846). Accepted as stage within the Pleistocene by Kay and Leighton (1933). Replaced by Holocene Stage.

St. Charles Substage

Leighton, 1960. Named for St. Charles, Kane County. Intraglacial substage between Tazewell and Cary Substages based on erosional contact between Marseilles (lower) and Minooka Drifts. Included in Woodfordian Substage.

Silveria Formation

Hershey, 1896a. Named for extinct Lake Silveria in Pecatonica River Basin. Included in Equality Formation where overlain by loess, in Winnebago Formation where overlain by till. Altonian.

Tazewell Substage, Loess

Leighton, 1933. Named for Tazewell County. Equated with "Early Wisconsin." Included the interval from the base of the Shelbyville Drift to the top of the Marseilles Drift. Included in the Woodfordian Substage. Tazewell Loess (Kay and Leighton, 1933) applied to loess overlying the Tazewell Drift; combined with Iowan Loess beneath the Tazewell Drift to form the Peorian Loess outside the Tazewell Drift border. Tazewell Loess replaced by Richland Loess (Frye and Willman, 1960).

Toronto Formation

Chamberlin, 1895. Named for Toronto, Ontario, Canada. Fossiliferous beds exposed along Don Valley in Toronto. Name applied to interglacial interval between the Iowan and Wisconsin stages of glaciation. Replaced by Peorian interglacial stage (Leverett, 1898a). See Peorian Substage.

Two Creeks Substage

Leighton, 1960. Named for Two Creeks, Manitowoc County, Wisconsin. Based on Two Creeks forest bed. Interval between the Mankato and Valders Substages. Replaced by Twocreekan Substage.

Upland Loess Member

Hershey, 1895. Named for topographic position. Upper member of the Columbia Formation. Defined as light brown, massive clay of glacial origin resting on Valley

Member and on the old interglacial soil on the ridges and on the "mounds." Correlated with upper loess and loam member of Columbia Formation in Mississippi Embayment (McGee, 1886a, 1891). Equivalent to Peoria Loess.

Valders Substage

Leighton, 1957a. Named for Valders, Wisconsin. Based on Valders Drift of Thwaites (1943; in abstract, 1937). Equivalent to the red drift above the Two Creeks forest bed. Introduced as a replacement for Mankato Substage (Thwaites, 1943). Replaced by Valderan (Frye and Willman, 1960).

Valley Loess Member

Hershey, 1895. Named for topographic position. Middle member of the Columbia Formation. Sand and loess in Pecatonica and Yellow Valleys. Sand, silt, and clay deposits in Lake Silveria (Altonian), included in Equality Formation, overlain by Peoria Loess.

White Rock Moraine

Leighton and Ekblaw, 1932. Named for White Rock, Ogle County. Correlated with Shelbyville (Woodfordian) Drift. In part replaced by Harrisville Moraine. In part included in Altonian (Frye et al., 1969).

Williana Formation

Fisk, 1938. Named for Williana, Grant Parish, Louisiana. Uppermost of three chert gravel terraces. Equivalent to Lancaster surface gravel (Leighton and Willman, 1949). Pliocene-Pleistocene. Included in the Mounds Formation.

Yankee Ridge Moraine

Anderson, 1960. Named for Yankee Ridge, a ridge southeast of Urbana, Champaign County. Included as part of the Urbana Moraine.

Zurich Moraine

Powers and Ekblaw, 1940. Named for Lake Zurich, Lake County. Approximate northward continuation of Palatine Moraine. Mapped as first moraine outside Palatine Moraine (Leighton and Willman, 1953). Not recognized at present as a moraine (Ekblaw, *in* Suter et al., 1959).

B. GLACIAL LAKES, LAKE STAGES, BEACHES, AND SHORELINES

Algoma, Lake

Leverett and Taylor, 1915. Named for Algoma Mills, Ontario. Youngest lake stage (596-foot elevation) to discharge through the Chicago Outlet before diversion by man. Holocene.

Algonquin, Lake

Spencer, 1891; in abstract, 1888. Named for Algonquin Indians. Lake succeeding Lake Chicago when retreating ice freed the Straits of Mackinac connecting lakes in the Huron and Michigan Basins. Reoccupied the Toleston Beach and discharged through the Chicago Outlet (605-foot elevation). Valderan.

Ancona, Lake

Willman and Payne, 1942. Named for Ancona, La Salle County. Ice-front lake on back slopes of Minonk Moraine. Woodfordian.

Bonpas, Lake (New)

Named for Bonpas River. Slackwater lake in Bonpas River Basin. Woodfordian-Valderan.

Bowmanville Stage

Baker, 1920b. Named for Bowmanville, Cook County, now part of Chicago. Low-water stage of Lake Chicago. See Bow-

manville Substage in Glossary A. Woodfordian.

Brussels, Lake

Leighton and Brophy, 1961. Named for Brussels, Calhoun County. See Brussels Formation. Illinoian or Altonian.

Cache, Lake (New)

Named for Cache River. Slackwater lake in Cache River Basin. Woodfordian-Valderan.

Calumet beach, lake stage, shoreline

Leverett, 1897. Named for Calumet River, Cook County. Middle beach of Lake Chicago (620-foot elevation). Woodfordian-Valderan.

Chicago, Lake

Leverett, 1897. Named for Chicago, Cook County. Lake in Lake Michigan Basin existing from Valparaiso retreat until Valders retreat. Early Lake Chicago existed during Valparaiso retreat and Tinley readvance. Woodfordian-Valderan.

Chippewa, Lake

Hough, 1955. Named for Chippewa Indians. Low lake stage (230-foot elevation) between Lake Algonquin and Lake Nipissing. Illinois part of the lake basin largely emergent. Approximate boundary between Valderan and Holocene.

Cordova, Lake

Shaffer, 1954a. Named for Cordova, Rock Island County. Lake formed in Mississippi Valley when Green River Lobe blocked Meredosia channel near Hillsdale. Woodfordian.

Cryder Lake

Culver, 1922. Named for Cryder School, Grundy County. Lake in Upper Illinois Valley marked by beaches and erosional benches cut by a lake-like expansion of the Chicago Outlet River. Woodfordian-Valderan.

Douglas, Lake

Gardiner, Odell, and Hallbick, 1966. Named for Douglas County. Lake formed behind Arcola Moraine. Woodfordian.

Embarras, Lake (New)

Named for Embarras River. Slackwater lake in Embarras River Basin. Woodfordian.

Evanston lake stage

Fisher, 1925. Named for Evanston, Cook County. Low-water stage of Lake Chicago between Glenwood and Calumet stages. Discontinued.

Freeport, Lake

Leighton and Brophy, 1966. Named for Freeport, Stephenson County. Lake formed in Pecatonica Valley when blocked by Altonian glacier (called Farmdale). A branch of Lake Silveria.

Glenwood beach, lake stage, shoreline

Leverett, 1897. Named for Glenwood, Cook County. Upper beach of Lake Chicago (640-foot elevation). Woodfordian.

Hennepin, Lake

McGee, 1890. Named for Père Hennepin, who first traversed its basin. According to McGee, a lake formed in Driftless Area when Minnesota-Iowa glacier met the Wisconsin-Illinois glacier south of Driftless Area. The loess in the Driftless Area was deposited in Lake Hennepin. Interpretation rejected because ice lobes did not meet (Leverett, 1899a).

Illinois, Lake

Leighton, *in* Fisher, 1925. Named for Illinois River. Lake formed in Illinois Valley when Bloomington Moraine dammed the valley at Peoria and existed until glacier retreated after building Marseilles Moraine. Present interpretation is that lake did not form until after the building of Dover Moraine. Woodfordian.

Kankakee Lake, Torrent, Flood

Bradley, 1870. Named for Kankakee River. Formed when Erie Lobe blocked discharge to Wabash Valley and meltwater from Lake Michigan, Saginaw, and Erie Lobes was concentrated in Kankakee Valley during building of Valparaiso Moraine. Renamed Kankakee Torrent (Ekblaw and

Athy, 1925). Now called Kankakee Flood. Woodfordian.

Kaskaskia, Lake (New)

Named for Kaskaskia River. Slackwater lake in Kaskaskia River Basin. Woodfordian.

Kickapoo, Lake

Willman and Payne, 1942. Named for North Kickapoo Creek, east of Marseilles, La Salle County. Previously called "Kickapoo beds" (Sauer, 1916). Post-Shelbyville, pre-Bloomington lake in Ticona Valley. Beds correlated with Lake Kickapoo at Wedron are Farmdalian (Leonard and Frye, 1960).

Lisbon, Lake

Willman and Payne, 1942. Named for Lisbon, Kendall County. Ice-front lake on back slope of Marseilles Moraine. Woodfordian.

Little Wabash, Lake (New)

Named for Little Wabash River. Slackwater lake in Little Wabash River Basin. Woodfordian-Valderan.

McKee, Lake

Frye and Willman, 1965a. Named for McKee Creek in Adams County. Lake formed when headwaters of McKee Creek were blocked by Illinoian glacier.

Matteson, Lake

Bretz, 1939. Named for Matteson, Cook County. Lake formed on back slope of Valparaiso Moraine in front of Tinley glacier. Woodfordian.

Milan, Lake

Shaffer, 1954a. Named for Milan, Rock Island County. Lake formed when advancing Woodfordian glacier blocked the Ancient Mississippi Valley at the Big Bend near Hennepin, Putnam County.

Moline, Lake

Anderson, 1968. Named for Moline, Rock Island County. Formed when advancing Illinoian glacier blocked the Ancient Mississippi Valley at the Big Bend near Hennepin, Putnam County.

Morris, Lake

Culver, 1922. Named for Morris, Grundy County. Lake in Morris Basin, a declining stage of the Kankakee Flood. Woodfordian.

Muddy, Lake

Shaw, 1911. Named for Big Muddy River. Slackwater lake in Big Muddy River Basin. Woodfordian-Valderan.

Nipissing, Lake

Taylor, 1894. Named for Lake Nipissing, Ontario, Canada. Also called Nipissing Great Lakes. Last discharge from Lake Michigan Basin at the Toleston level (605-foot elevation). Holocene.

Odell, Lake (New)

Mapped by Ekblaw, *in* Flint et al. (1959). Named for Odell, Livingston County. Lake on Marseilles Moraine. Woodfordian.

Orland, Lake

Bretz, 1939. Named for Orland Park, Cook County. Lake on back slope of Valparaiso Moraine in front of Tinley glacier. Woodfordian.

Ottawa, Lake

Willman and Payne, 1942. Named for Ottawa, La Salle County. Kankakee Flood lake in Fox and Illinois Valleys between Farm Ridge Moraine and Marseilles Morainic System. Woodfordian.

Pearl, Lake

Leighton and Brophy, 1966. Named for Pearl City, Stephenson County. Lake formed in Yellow Creek Valley when it was blocked by Altonian glacier (called Farmdale). A branch of Lake Silveria.

Pecatonica, Lake

Hershey, 1896a. Named for Pecatonica, Winnebago County. Same as Lake Silveria.

Altonian. Rejected because name is used for the Pecatonica Lobe.

Pingree, Lake

Named for Pingree Grove, Kane County, by Leighton, MacClintock, and Powers in manuscript. Lake in Gilberts Moraine. Woodfordian.

Pontiac, Lake

Willman and Payne, 1942. Named for Pontiac, Livingston County. Kankakee Flood lake in Vermilion Valley between Minonk, Farm Ridge, and Marseilles Moraines. Woodfordian.

Saline, Lake (New)

Named for Saline River. Slackwater lake in Saline River Basin. Woodfordian.

Savanna, Lake

Shaffer, 1954a. Named for Savanna, Carroll County. Lake formed in Mississippi Valley when Green River Lobe blocked the valley at Fulton. Existence of lake questioned because of doubt that the ice reached Fulton.

Seward, Lake

Leighton and Brophy, 1960. Named for Seward, Stephenson County. Lake on south side of Pecatonica Lobe of Altonian glacier (called Farmdale).

Silver, Lake

Leighton and Brophy, 1966. Named for Silver Creek, southeast of Freeport, Stephenson County. Lake on south side of Pecatonica Lobe of Altonian glacier (called Farmdale).

Silveria, Lake

Hershey, 1896d. Probably named for Silver Creek or Silver Township, southeast of Freeport, Stephenson County. Lake in Pecatonica River and Yellow Creek Valleys formed when Pecatonica Lobe of Altonian glacier invaded the valley from the east.

Skillet, Lake (New)

Named for Skillet Creek. Slackwater lake in basin of Skillet Creek. Woodfordian.

Steger, Lake

Bretz, 1939. Named for Steger, Cook County. Lake on back slope of Valparaiso Morainic System in front of Tinley glacier. Woodfordian.

Tinley, Lake

Bretz, 1939. Named for Tinley Park, Cook County. Lake on back slope of Valparaiso Morainic System in front of Tinley glacier.

Toleston beach, lake stage, shoreline

Leverett, 1897. Named for Toleston, Indiana. Misspelled Tolleston by Leverett. Lowest beach of Lake Chicago. Reoccupied by Lake Algonquin and Lake Nipissing. Valderan.

Watseka, Lake

Willman and Payne, 1942. Named for Watseka, Iroquois County, by George E. Ekblaw. Kankakee Flood lake between the Chatsworth Moraine, Marseilles Morainic System, the St. Anne Moraine, and the Iroquois Moraine. Woodfordian.

Wauponsee, Lake

Willman and Payne, 1942. Named for Wauponsee, Grundy County. Kankakee Flood lake between the Marseilles and Valparaiso Morainic Systems. Woodfordian.

C. PENEPLAINS, STRATHS, AND EROSION SURFACES

Buzzards Point Plain

Salisbury, *in* Weller et al., 1920. Named for Buzzards Point, 2 miles northwest of Karbers Ridge, Hardin County. Highest erosion surface in Hardin County. Correlated with Dodgeville Peneplain (Horberg, 1946b).

Calhoun Peneplain

Rubey, *in* Horberg, 1946b; Rubey, 1952. Named for Calhoun County. Correlated with Lancaster and Ozark Peneplains.

Central Illinois Peneplain

Horberg, 1946b. Named for Central Illinois. Lowest widespread peneplain surface but higher than Havana Strath. Correlated with McFarlan Plain. Renamed Smithland Surface (Leighton and Willman, 1949).

Dodgeville Peneplain

Trowbridge, 1921. Named for Dodgeville, Wisconsin. Peneplain No. 1 of Hershey (1896c). Highest erosional surface preserved only on highest hills in Driftless Area of Jo Daviess County and Shawnee Hills of southern Illinois (Horberg, 1946b). Correlated with Buzzards Point Plain.

Elizabethtown Plain

Salisbury, *in* Weller et al., 1920. Named for Elizabethtown, Hardin County. Lowest erosional surface in Hardin County. Possibly equivalent to the Havana Strath.

Havana Strath

Horberg, 1946b. Named for Havana, Mason County. Broad-valley erosional surface in which the deep stage of the major valleys is entrenched. Correlated with surface on which Fisk's (1938) Montgomery Formation is deposited (Leighton and Willman, 1949).

Karbers Ridge Plain

Salisbury, *in* Weller et al., 1920. Named for Karbers Ridge, Hardin County. Erosional surface between the Buzzards Point and McFarlan Peneplains. Possibly equivalent to the Lancaster and Ozark Peneplains.

Lancaster Peneplain

Grant and Burchard, 1907. Named for Lancaster, Wisconsin. Peneplain No. 2 of Hershey (1896c). Major upland surface developed on resistant limestone and dolomite formations in northern and western Illinois and the Shawnee Hills of southern Illinois. Correlated with Ozark and Calhoun surfaces (Horberg, 1946b). Correlated with surface overlain by Fisk's (1938) Williana Formation (Leighton and Willman, 1949).

McFarlan Plain

Salisbury, *in* Weller et al., 1920. Named for McFarlan Township, Hardin County. Correlated with Central Illinois Peneplain (Horberg, 1946b).

Metz Creek Terrace

Rubey, 1952. Named for Metz Creek, a small creek in Calhoun County. An erosional surface cut into Brussels Terrace; no deposits specifically related to it.

Ozark Peneplain

Flint, 1941. Named for Ozark Mountains. Correlated with Lancaster and Calhoun Peneplains (Horberg, 1946b). "Ozarkian" (Hershey, 1896b) was proposed for the interval of erosion following deposition of "Lafayette Gravel" and before "Kansan" glaciation.

Smithland Surface

Leighton and Willman, 1949. Named for Smithland, Kentucky. Replacement for Central Illinois Peneplain of Horberg (1946b). Correlated with surface overlain by Fisk's (1938) Bentley Formation.

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TABLE 1—SELECTED STRATIGRAPHICALLY SIGNIFICANT RADIOCARBON DATES FROM ILLINOIS
(94 dates from 30 counties)

Laboratory no.	Date B.P.	Stratigraphic unit or material sampled	Location	Reference
C-364	3,469 ± 230	Algonquin sediments	Univ. Chicago Campus, Cook Co.	Libby, 1955
C-674	8,200 ± 480	Toleston sediments	Dolton, Cook Co.	Libby, 1955
C-801	10,972 ± 350 (av. of 2 runs)	Glenwood sediments	SW NW SW 20, 35N-15W, Cook Co.	Libby, 1955
GrN-4408 (rerun of I-848)	41,000 ± 1,500	Winnebago Fm., Plano Silt M.*	SE SW NE 7, 41N-7E, Kane Co.	Kempton & Hackett, 1968a
GrN-4468 (rerun of I-1197)	32,600 ± 520	Winnebago Fm., Plano Silt M.*	SE SE SE 15, 39N-7E, Kane Co.	Kempton & Hackett, 1968a
I-847	38,000 ± 3,000	Winnebago Fm., Plano Silt M.*	NW SW SE 12, 43N-5E, McHenry Co.	Kempton & Hackett, 1968a
I-848	>40,000	Winnebago Fm., Plano Silt M.*	SE SW NE 7, 41N-7E, Kane Co.	
I-849	25,600 ± 800	Robein Silt*	NW SW NW 15, 45N-6E, McHenry Co.	Kempton & Hackett, 1968a
I-1196	10,980 ± 350	Wood, mastodon site	NE 11, 39N-10E, Du Page Co.	Block, 1964
I-1197	>40,000	Winnebago Fm., Plano Silt M.*	SE SE SE 15, 39N-7E, Kane Co.	Kempton & Hackett, 1968a
I-1624	25,300 ± 1,100	Robein Silt*	NE NE SE 30, 43N-8E, McHenry Co.	Kempton & Hackett, 1968a
I-1625	26,900 + 1,600, — 1,300	Robein Silt*	SE NE SW 18, 42N-7E, Kane Co.	Kempton & Hackett, 1968a
I-1626	>36,000	Winnebago Fm., Plano Silt M.	SE SW NE 1, 37N-6E, Kendall Co.	Kempton & Hackett, 1968b
I-1719	16,000 ± 340	Peoria Loess	SW SE SW 32, 11N-3W, Warren Co.	Frye, Glass, & Willman, 1968
I-1720	13,700 ± 230	Peoria Loess	NE NE SE 20, 12N-4W, Henderson Co.	Frye, Glass, & Willman, 1968
I-1962	>39,900	Berry Clay Member	SW NW SE 1, 26N-6E, Stephenson Co.	Folmer, 1967
I-2218	26,500 + 1,000, — 900	Robein Silt*	NW SW SE 1, 25N-1E, Woodford Co.	Kempton, DuMontelle, & Glass, in press
I-2219	>39,900	Illinoian or older*	NW SW SE 1, 25N-1E, Woodford Co.	
I-2220	27,200 + 1,000, — 900	Robein Silt*	NE NE SE 20, 22N-4E, McLean Co.	Kempton, DuMontelle, & Glass, in press
I-2517	21,950 ± 500	Robein Silt*	NW SE NW 1, 21N-5E, De Witt Co.	Kempton, DuMontelle, & Glass, in press
I-2518	22,450 ± 500	Wedron Fm., Tiskilwa M.*	NW SW NW 33, 24N-2E, McLean Co.	Kempton, DuMontelle, & Glass, in press
I-2519	20,000 ± 400	Robein Silt*	NE NE SW 35, 15N-10E, Douglas Co.	
I-2783	23,000 + 2,100, — 1,950	Robein Silt*	SE NE NE 28, 42N-9E, Cook Co.	Kempton & Hackett, 1968b
I-2784	23,750 + 1,050, — 950	Robein Silt*	SW NW SW 1, 41N-2E, Ogle Co.	Frye et al., 1969
I-2785	24,600 ± 750	Robein Silt*	SW SE SW 5, 21N-5E, McLean Co.	Kempton, DuMontelle, & Glass, in press

* Sample from subsurface core.

(Continued on next page)

TABLE 1—Continued

Laboratory no.	Date B.P.	Stratigraphic unit or material sampled	Location	Reference
IJ-281	6,600 ± 200	50 feet below surface in Cahokia Fm. (alluvium), a tree trunk in large diameter well	NE SE NW 29, 5N-9W, Madison Co.	Hubbs, Bien, & Suess, 1963
ISGS-5	>22,000	Gyttja*	SW NE SW 3, 5N-1W, Fayette Co.	Kim, in press
ISGS-6	27,500 ± 500	Robein Silt	SE NE NE 33, 21N-5E, Whiteside Co.	Kim & Ruch, 1969
ISGS-7	>27,850	Robein Silt	NE NE NW 8, 22N-8E, Ogle Co.	Kim & Ruch, 1969
ISGS-9	>22,300	Gyttja*	SW NE SW 3, 5N-1W, Fayette Co.	Kim, in press
ISGS-10	>27,900	Gyttja*	SW NE SW 3, 5N-1W, Fayette Co.	Kim, in press
ISGS-11	38,100 ± 1,000	Gyttja*	SW NE SW 3, 5N-1W, Fayette Co.	Kim, in press
ISGS-12	23,900 ± 200	Robein Silt	NW NE NW 32, 25N-1W, McLean Co.	Kim, in press
ISGS-13	>40,000	Gyttja*	SW NE SW 3, 5N-1W, Fayette Co.	Kim, in press
ISGS-14	8,300 ± 1,900	Organic silty clay*	SW NE SW 3, 5N-1W, Fayette Co.	Kim, in press
ISGS-15	>38,000	Illinoian	NE SW SW 33, 20N-12W, Vermilion Co.	Kim, in press
ISGS-16	>40,000	Illinoian or older	NW SW NE 1, 25N-2E, McLean Co.	Kim, in press
ISGS-17A	7,490 ± 200	Mastodon bone (2N HCl)	SW SW 15, 19N-9E, Champaign Co.	Kim, in press
ISGS-17B	8,330 ± 200	Mastodon bone (0.1N NaOH, 2N HCl)	SW SW 15, 19N-9E, Champaign Co.	Kim, in press
ISGS-17C	9,190 ± 200	Ivory (mastodon)	SW SW 15, 19N-9E, Champaign Co.	Kim, in press
ISGS-19	>40,000	Illinoian	NW SW SW 31, 6N-1W, Fayette Co.	Kim, in press
ISGS-21	25,500 ± 600	Robein Silt	NE SW NW 13, 16N-1W, Macon Co.	Kim, in press
ISGS-22	>40,000	Silt*	SW NE SW 3, 5N-1W, Fayette Co.	Kim, in press
ISGS-23	>40,000	Illinoian	SE NE NE 2, 19N-12W, Vermilion Co.	Kim, in press
ISGS-24	27,200 ± 400	Robein Silt*	NE NW NE 32, 28N-5E, Jo Daviess Co.	Kim, in press
ISGS-25	>33,000	Roxana Silt*	NE SW NW 13, 16N-1W, Macon Co.	Kim, in press
ISGS-26	20,000 ± 200	Robein Silt	NE SE SW 8, 11N-4E, Shelby Co.	Kim, in press
ISGS-27	19,500 ± 200	Morton Loess	NW NE SW 5, 12N-10E, Coles Co.	Kim, in press
ISGS-28	21,300 ± 200	Robein Silt	SW NE NW 5, 12N-10E, Coles Co.	Kim, in press
ISGS-29	>47,000	Illinoian	SW NW NW 4, 19N-12W, Vermilion Co.	Kim, in press
ISGS-30	26,300 ± 400	Robein Silt*	NE NW NE 32, 28N-5E, Jo Daviess Co.	Kim, in press
ISGS-31	25,900 ± 500	Wood in Tiskilwa Till M. of Wedron Fm.	NW SE NW 9, 34N-4E, La Salle Co.	Kim, in press
ISGS-32	21,300 ± 500	Robein Silt	NE SE SW 8, 11N-4E, Shelby Co.	Kim, in press
OWU-33	4,003 ± 97	Grays Lake sediments (8.7-8.83 m. down)	Lake Co. (42°20′ N, 88°3′ W)	Ogden & Hay, 1964
OWU-34	6,539 ± 97	Grays Lake sediments (9.92-10.08 m. down)	Lake Co. (42°21′ N, 88°3′ W)	Ogden & Hay, 1964

* Sample from subsurface core.

TABLE 1—Continued

Laboratory no.	Date B.P.	Stratigraphic unit or material sampled	Location	Reference
W-68	22,900 ± 900	Robein Silt	SW SE 30, 26N-3W, Tazewell Co.	Suess, 1954
W-69	25,100 ± 800	Robein Silt	SW SE 30, 26N-3W, Tazewell Co.	Suess, 1954
W-79	24,000 ± 700	Robein Silt	SE SE SW 9, 34N-4E, La Salle Co.	Suess, 1954
W-140	12,650 ± 350	Glenwood beach	SW NW SW 20, 35N-15W, Cook Co.	Rubin & Suess, 1955
W-161	12,200 ± 350	Glenwood beach	SW NW SW 20, 35N-15W, Cook Co.	Rubin & Suess, 1955
W-187	19,200 ± 700	Wedron Fm., Delavan Till M.	SE SE 36, 26N-4W, Tazewell Co.	Rubin & Suess, 1955
W-230	<200	Cahokia Alluvium, 79 feet below surface	SW NW NE 27, 1N-10W, Madison Co.	Rubin & Alexander, 1958
W-292	25,000 ± 800	Henry Fm., 85 feet below surface	SE NW SE 6, 3N-9W, Madison Co.	Rubin & Alexander, 1958
W-317	8,340 ± 250	Cahokia Alluvium, 60 feet below surface	SE SW NW 20, 3N-9W, Madison Co.	Rubin & Alexander, 1958
W-333	25,700 ± 800	Robein Silt	SE NW 8, 16N-10E, Bureau Co.	Rubin & Alexander, 1958
W-334	22,450 ± 1,000	Robein Silt	SE NW 8, 6N-10E, Bureau Co.	Rubin & Alexander, 1958
W-349	20,340 ± 750	Morton Loess	SW SE 30, 26N-3W, Tazewell Co.	Rubin & Alexander, 1958
W-381	15,600 ± 600	Henry Fm.	NE 33, 4N-3E, Fulton Co.	Rubin & Alexander, 1958
W-399	20,700 ± 650	Morton Loess	SW SE 30, 26N-3W, Tazewell Co.	Rubin & Alexander, 1958
W-406	26,150 ± 700	Robein Silt	NW NE NW 32, 25N-1W, McLean Co.	Rubin & Alexander, 1958
W-425	5,370 ± 200	Lake Chicago deposits	SE NW NW 12, 40N-13E, Cook Co.	Rubin & Alexander, 1958
W-426	10,700 ± 300	Lake Chicago deposits	NE NE NE 2, 40N-13E, Cook Co.	Rubin & Alexander, 1958
W-483	20,500 ± 600	Morton Loess	NE SW 32, 25N-1W, McLean Co.	Rubin & Alexander, 1958
W-524	18,460 ± 500	Wedron Fm., Delavan Till M.	NW 31, 26N-3W, Tazewell Co.	Rubin & Alexander, 1960
W-642	26,200 ± 800	Robein Silt	SE SW SE 5, 16N-10E, Bureau Co.	Rubin & Alexander, 1960
W-725	4,030 ± 150	Toleston beach	SW NE 19, 41N-14E, Cook Co. (800 Hinman Ave., Evanston, Ill.)	Rubin & Alexander, 1960
W-729	35,200 ± 1,000	Roxana Silt, Meadow Loess M.	Center SE 20, 3N-8W, Madison Co.	Rubin & Alexander, 1960
W-730	17,100 ± 300	Peoria Loess	NW SW 4, 3N-8W, Madison Co.	Rubin & Alexander, 1960
W-745	23,500 ± 400	Robein Silt	SE NW 33, 4N-3E, Fulton Co.	Rubin & Alexander, 1960
W-823	4,840 ± 300	Terrace silt	NW SW SW 25, 17S-3W, Union Co.	Rubin & Alexander, 1960
W-849	23,700 ± 550	Robein Silt	SE 13, 6N-4E, Fulton Co.	Rubin & Alexander, 1960
W-853	25,500 ± 600	Robein Silt	SE 13, 6N-4E, Fulton Co.	Rubin & Alexander, 1960
W-868	27,500 ± 900	Roxana Silt	NW NW SW 4, 3N-8W, Madison Co.	Rubin & Alexander, 1960
W-869	37,000 ± 1,500	Roxana Silt, Meadow Loess M.	NE NE SW 33, 14S-3W, Alexander Co.	Rubin & Alexander, 1960
W-870	20,300 ± 400	Peoria Loess	NE NE SW 28, 4N-3E, Fulton Co.	Rubin & Alexander, 1960
W-871	26,800 ± 700	Robein Silt	SE SE SW 9, 34N-4E, La Salle Co.	Rubin & Alexander, 1960
W-1055	17,950 ± 550	Peoria Loess	SE NW NE 29, 3N-8W, Madison Co.	Ives et al., 1964

(Continued on next page)

TABLE 1—Continued

Laboratory no.	Date B.P.	Stratigraphic unit or material sampled	Location	Reference
W-1144	>38,000	Winnebago Fm., Plano Silt M.*	SW NE NW 31, 43N-5E, McHenry Co.	Ives et al., 1964
W-1381	>32,000	Winnebago Fm.	NE NE SW 29, 41N-5E, De Kalb Co.	Kempton, 1966
W-1383	13,290 ± 350	Henry Fm.	NE NW NE 30, 19N-8E, Champaign Co.	
W-1384	9,920 ± 300	Henry Fm.	SE NE NE 3, 19N-9E, Champaign Co.	
W-1385	12,000 ± 400	Henry Fm.	NE NE SW 29, 41N-5E, De Kalb Co.	Kempton, 1966
W-1450 (check run of I-847)	35,000 ± 2,500	Winnebago Fm., Plano Silt M.*	NW SW SE 12, 43N-5E, McHenry Co.	Kempton & Hackett, 1968a
W-2009	>40,000	Illinoian (?)*	NW SW NE 1, 25N-2E, McLean Co.	Marsters, Spiken, & Rubin, 1969

* Sample from subsurface core.

TABLE 2—TYPICAL COMPOSITIONS OF GLACIAL TILL UNITS

Rock-stratigraphic units	Matrix grain size (%)			Clay mineral composition (%)			Carbonate minerals (counts/sec) $<2\mu$	Garnet to epidote ratio
	Sand	Silt	Clay	Expandable clay minerals	Illite	Kaolinite and chlorite	Calcite Dolomite	
WEDRON FORMATION								
Wadsworth Till Member	11 12	38 37	51 51	19 10	67 77	14 13	c < d	33:67
Haeger Till Member	39	39	22	21	63	16	c < d	28:72
Yorkville Till Member	12	38	50	6	78	16	c < d	32:68
Malden Till Member	22	44	34	8	77	15	c < d	45:55
Tiskilwa Till Member	31	37	32	19	65	16	c < d	47:53
Delavan Till Member	30	39	31	8	71	21	c < d	56:44
Esmond Till Member	24 13	43 40	33 47	6	81	13	c < d	42:58
Lee Center Till Member	37	38	25	13	67	20	c < d	45:55
WINNEBAGO FORMATION								
Capron Till Member	43 25	33 43	24 32	37 29	50 58	13 13	c < d	38:62
Argyle Till Member	54	31	15	23	62	15	c < d	41:59
GLASFORD FORMATION								
Undiff. (SE Illinois)	35	44	21	19	61	20	c = d	71:29
Radnor Till Member	27	46	27	8	77	15	c < d	55:45
Sterling Till Member	25	45	30	7	81	12	c < d	
Hulick Till Member	28	45	27	8	65	27	c < d	48:52
Winslow Till Member	17	43	40	37	52	11	c < d	37:63
Ogle Till Member	32	45	23	60 37 22	29 48 68	11 15 10	c < d	58:42
Kellerville Till Member	28	45	27	39	40	21	c < d	53:47
BANNER FORMATION								
(western Illinois)	32	40	28	69	11	20	c > d	30:70
(eastern Illinois)				8	65	27	c > d	81:19

TABLE 3—COMPOSITION OF WEDRON FORMATION
(X-ray analyses by H. D. Glass, Illinois State Geological Survey)

Drift	Matrix grain size (%)			Clay minerals ($<2\mu$ fraction) (%)			Carbonate minerals ($<2\mu$ fraction) (counts/sec)		Munsell color notation	Sample no.	Location
	Sand	Silt	Clay	Expandable clay minerals	Illite	Kaolinite and chlorite	Calcite	Dolomite			
WADSWORTH TILL MEMBER											
Blodgett	9	48	43	18	69	13	31	35	10YR 5/3	P-6983	NE SW NE 12, 44N-11E, Lake
Deerfield	18	35	47	19	65	16	27	45	10YR 5/3	6980	SE NE NW 26, 45N-11E, Lake
Highland Park	8	36	56	18	68	14	36	76	10YR 6/3	6982	SE SE SW 30, 46N-12E, Lake
Keeneyville	13	38	49	12	75	13	25	42	10YR 5/4	7001	NW NE NW 6, 37N-11E, Du Page
Keeneyville	11	32	57	6	81	13	18	40	10YR 5/3	7017	NE NW NW 2, 34N-12E, Will
Palatine	20	38	42	7	81	12	0	35	10YR 5/4	6985	NW NE NW 1, 40N-10E, Du Page
Park Ridge	7	33	60	21	66	13	0	26	10YR 5/3	6979	SE SE SW 34, 45N-11E, Lake
Roselle	17	40	43	10	75	15	0	24	2.5Y 5/4	6986	SE SE NW 14, 40N-10E, Du Page
Tinley	16	52	32	17	74	9	10	38	10YR 5/4	6977	NW NE NW 18, 44N-11E, Lake
Tinley	6	35	59	14	73	13	25	36	10YR 5/4	7021	NE NW SW 30, 35N-14E, Cook
Valparaiso	16	27	57	15	73	12	36	65	10YR 6/4	6975	SE SE NW 30, 44N-10E, Lake
West Chicago	18	36	46	7	80	13	16	44	10YR 5/4	6989	SE SE SE 16, 40N-9E, Du Page
West Chicago	10	41	49	10	77	13	22	33	2.5Y 5/4	6998	NW SW NW 10, 37N-10E, Will
West Chicago	9	45	46	11	77	12	43	36	10YR 5/4	7042	NW NE NW 31, 34N-13E, Will
Westmont	13	39	48	11	77	12	7	27	10YR 5/3	7019	NE NW NW 31, 35N-13E, Cook
Wheaton	11	37	52	11	76	13	22	38	10YR 5/4	6988	SE SW NE 19, 40N-10E, Du Page
Wheaton	14	40	46	15	73	12	11	27	10YR 5/4	6999	SW SE SW 2, 37N-10E, Will
Wheaton	8	42	50	8	77	15	0	26	2.5Y 4/4	7015	SW NW SW 4, 34N-12E, Will
Wheaton	8	44	48	6	85	9	0	25	2.5Y 5/4	7043	SE SE SE 19, 34N-13E, Will
HAEGER TILL MEMBER											
Cary	25	55	20	21	63	16	0	70	10YR 5/6	P-6973	SE SE SE 29, 43N-9E, McHenry
Fox Lake	12	36	52	14	73	13	28	32	10YR 5/4	6974	NE NW SW 24, 43N-9E, Lake
West Chicago	51	42	7	5	80	15	—	—	—	401	NW SW SW 19, 43N-9E, McHenry
West Chicago	57	29	14	13	65	22	—	—	—	407	NE NW NE 28, 46N-6E, McHenry
West Chicago	52	32	16	52	36	12	0	75	10YR 5/6	6972	NW NW NE 36, 43N-8E, McHenry

TABLE 3—Continued

Drift	Matrix grain size (%)			Clay minerals ($<2\mu$ fraction) (%)			Carbonate minerals ($<2\mu$ fraction) (counts/sec)		Munsell color notation	Sample no.	Location
	Sand	Silt	Clay	Expandable clay minerals	Illite	Kaolinite and chlorite	Calcite	Dolomite			
YORKVILLE TILL MEMBER											
Barlina	6	32	62	6	82	12	26	44	10YR 6/3	P-6971	SE SE NE 25, 43N-7E, McHenry
Cullom	4	52	44	7	77	16	0	23	5YR 5/3	7033	SW SW NW 16, 28N-9E, Ford
Huntley	19	47	34	6	83	11	0	38	10YR 5/3	6970	NW SE NW 28, 43N-7E, McHenry
Manhattan	14	40	46	10	76	14	25	37	10YR 5/3	7011	NE NE NE 21, 34N-11E, Will
Manhattan	10	41	49	13	73	14	22	28	2.5Y 5/3	7039	NW NW SW 32, 34N-12E, Will
Marseilles	21	40	39	10	79	11	3	31	10YR 5/4	6994	SE NE NW 34, 37N-8E, Kendall
Marseilles	8	33	59	6	78	16	22	27	2.5Y 5/2	7035	NW NW NW 34, 29N-9E, Ford
Minooka	14	40	46	15	72	13	12	34	2.5Y 6/4	6993	NW SW SW 25, 37N-8E, Kendall
Minooka	4	34	62	6	78	16	16	37	2.5Y 5/4	7007	NW NW NW 23, 34N-8E, Grundy
Rockdale	13	39	48	11	76	13	25	28	10YR 5/4	6996	SW NW SW 29, 37N-10E, Will
Rockdale	14	42	44	10	75	15	22	42	2.5Y 5/4	7009	NE NE NW 33, 34N-10E, Will
St. Anne	5	34	61	4	82	14	26	38	5Y 5/2	7048	SE SE SW 32, 29N-11W, Iroquois
Wilton Center	14	38	48	9	75	16	17	20	10YR 5/4	7010	NW NW NE 13, 34N-10E, Will
Wilton Center	19	35	46	10	80	10	30	44	2.5Y 5/4	7047	NE NW NE 25, 32N-13E, Kankakee
MALDEN TILL MEMBER											
Arlington	13	37	50	9	76	15	14	27	10YR 5/4	P-6870	SW SW NE 3, 16N-10E, Bureau
Arlington	23	47	30	20	71	9	8	30	10YR 5/4	6954	SW SE SW 3, 36N-1E, La Salle
Arlington	35	36	29	24	64	12	31	41	10YR 5/4	6966	SE NW SW 3, 39N-5E, De Kalb
Bloomington	22	42	41	7	78	15	9	23	2.5Y 6/4	7060	NW NW SW 30, 23N-6E, McLean
Bloomington	27	40	33	12	81	7	11	31	2.5Y 5/4	7085	NE NE SE 28, 23N-3E, McLean
Chatsworth	12	37	51	5	86	9	0	26	2.5Y 5/2	7032	SW NW SE 10, 26N-8E, Livingston
Dover	20	38	42	8	77	15	30	50	10YR 5/3	6867	SW SE SE 5, 16N-10E, Bureau
Dover	28	48	24	13	76	11	20	32	10YR 6/6	6872	NW SW SE 17, 17N-10E, Bureau
El Paso	11	42	47	3	80	17	15	22	2.5Y 6/4	7065	NE NE NE 33, 25N-5E, McLean
Eureka	23	47	30	5	80	15	0	24	2.5Y 6/4	7063	NW NW NW 15, 23N-5E, McLean

(Continued on next page)

TABLE 3—Continued

Drift	Matrix grain size (%)			Clay minerals ($<2\mu$ fraction) (%)			Carbonate minerals ($<2\mu$ fraction) (counts/sec)		Munsell color notation	Sample no.	Location
	Sand	Silt	Clay	Expandable clay minerals	Illite	Kaolinite and chlorite	Calcite	Dolomite			
Eureka	23	49	28	5	83	12	0	19	2.5Y 5/4	7076	NW NW SW 6, 23N-4E, McLean
Fletchers	25	47	28	3	85	12	7	32	2.5Y 6/4	7064	NE SE SE 4, 23N-5E, McLean
Gilberts	53	28	19	20	64	16	32	60	10YR 5/4	6969	NW NW NW 10, 42N-7E, Kane
La Moille	21	50	29	21	69	10	22	60	10YR 5/4	6910	SE NE SE 23, 37N-1E, Lee
La Moille	52	35	13	20	66	14	14	60	10YR 5/8	6918	SE SE SW 34, 38N-2E, Lee
Minonk	8	42	50	4	83	13	0	25	2.5Y 6/4	7066	¼ mi. N. SE/c, 4, 25N-5E, McLean
Normal	11	39	50	9	78	13	12	27	2.5Y 6/4	7061	NE NE SE 22, 23N-5E, McLean
Normal	3	27	70	5	81	14	15	21	5Y 6/3	7075	NE NE SE 12, 23N-3E, McLean
Paw Paw	15	47	38	11	76	13	27	45	10YR 5/4	6911	NE NE NE 36, 37N-1E, Lee
Shabbona	58	25	17	22	64	14	15	46	10YR 6/6	6965	SE SE NE 33, 40N-5E, De Kalb
TISKILWA TILL MEMBER											
Bloomington	30	36	34	20	64	16	34	36	5YR 5/3	P-6866	SW SE SE 5, 16N-10E, Bureau
Bloomington	27	38	35	16	72	12	12	36	7.5YR 5/4	7100	SW SE NW 15, 24N-2W, Tazewell
Elburn	39	28	33	32	55	13	0	60	5YR 5/6	6963	SE NE SW 8, 40N-5E, De Kalb
Marengo	30	27	43	34	58	8	0	0	5YR 4/3	6967	NE NE SW 25, 42N-6E, Kane
Paw Paw	32	36	32	24	60	16	33	53	5YR 6/4	6929	NW SW SW 17, 39N-3E, De Kalb
Providence	29	39	32	24	59	17	25	40	5YR 5/4	6896	NE NW NE 36, 20N-11E, Lee
Providence	33	34	33	23	62	15	30	58	5YR 5/4	6919	NW NW NW 34, 38N-2E, Lee
Sheffield	28	40	32	22	62	16	24	42	5YR 5/3	6889	SW SE NW 2, 19N-10E, Lee
Van Orin	31	36	33	32	54	14	27	38	5YR 5/4	6880	SE NE NW 16, 18N-10E, Bureau
DELAVAN TILL MEMBER											
Shelbyville	—	—	—	8	81	11	25	29	10YR 5/4	P-1891	NW SW SW 16, 22N-3W, Tazewell
Shirley	32	41	27	19	72	9	6	23	2.5Y 5/4	7082	NE NE NW 13, 22N-3E, McLean

TABLE 3—Continued

Drift	Matrix grain size (%)			Clay minerals ($<2\mu$ fraction) (%)			Carbonate minerals ($<2\mu$ fraction) (counts/sec)		Munsell color notation	Sample no.	Location
	Sand	Silt	Clay	Expandable clay minerals	Illite	Kaolinite and chlorite	Calcite	Dolomite			
LEE CENTER TILL MEMBER											
	29	39	32	10	77	13	20	29	10YR 4/3	P-6863	SW SE SE 5, 16N-10E, Bureau
	31	40	29	16	70	14	20	36	10YR 5/4	6892	NW NW SW 20, 20N-11E, Lee
ESMOND TILL MEMBER											
	9	33	58	3	82	15	23	35	—	P-2086	NW SW NW 27, 43N-2E, Winnebago
	8	38	54	10	81	9	14	32	—	8158	NW SW NE 25, 22N-9E, Lee
WEDRON FORMATION—(UNDIFFERENTIATED)											
Champaign	17	42	41	2	86	12	0	20	5Y 5/3	P-7057	NW NE NW 9, 22N-6E, McLean
Ellis	6	30	64	7	84	9	17	19	2.5Y 5/2	7026	NW NW SW 10, 24N-9E, Ford
Gifford	11	45	44	3	85	12	0	25	10YR 5/3	7022	NW SW NW 13, 22N-9E, Champaign
Gilman	4	35	61	7	76	17	21	30	2.5Y 5/4	7055	SE NE NE 12, 25N-12W, Iroquois
Iroquois	39	28	33	8	80	12	21	24	2.5Y 5/4	7052	SE SE NE 23, 28N-11W, Iroquois
Paxton	8	36	56	5	85	10	10	23	2.5Y 6/2	7023	SW NW NW 18, 23N-10E, Ford
Shelbyville	26	42	32	17	70	13	16	32	—	6111	SE NE SW 36, 15N-1E, Macon

TABLE 4—AVERAGES OF ANALYSES OF SELECTED HEAVY AND LIGHT MINERALS
(Analyses of size fraction 0.062—0.250 mm)
(From Frye, Glass, and Willman, 1962; Frye, Willman, and Glass, 1964; Willman, Glass, and Frye, 1963)

Rock-stratigraphic unit and geographic region	Number of samples	Black opaque (%)	Translucent heavy minerals (%)										Light minerals (%)		
			Tourmaline	Zircon	Garnet	Epidote	Staurolite	Actinolite	Hornblende	Enstatite	Hypersthene	Diopside, augite and other	K feldspar	Na-Ca feldspar	Quartz and other
SILT															
Richland Loess	3	14	1	4	14	17	0	0	58	0	1	0	16	6	78
Peoria Loess															
(Ill. River Valley)	18	20	1	8	8	22	0	1	55	1	tr.	tr.	15	9	76
(Rock River Valley)	4	15	2	9	8	6	0	0	56	1	1	1	15	6	79
(Upper Miss. Valley)	20	15	2	5	6	23	1	tr.	59	tr.	1	tr.	16	9	75
(Lower Miss. Valley)	11	22	3	15	11	26	tr.	4	33	1	tr.	1	15	11	74
(Ohio River Valley)	3	13	3	5	19	13	0	3	50	1	2	1	13	8	79
(Wabash River Valley)	1	4	1	3	12	10	0	7	66	0	1	0	—	—	—
Morton Loess	5	13	1	6	8	14	0	1	64	1	0	1	14	8	78
Robein Silt	3	19	tr.	11	13	22	0	0	40	0	0	0	17	9	74
Roxana Silt															
(Ill. River Valley)	14	19	2	8	11	28	tr.	1	45	2	tr.	1	14	8	78
Meadow Loess Member	38	17	2	11	10	24	tr.	2	49	1	tr.	1	17	9	74
McDonough & Markham Members	14	17	4	10	14	26	tr.	1	32	1	tr.	1	13	8	79
Roxana Silt															
(Mid. Miss. Valley)	5	33	7	8	12	29	8	0	31	tr.	0	0	—	—	—
(Ohio River Valley)	3	9	10	26	8	18	1	tr.	31	0	0	0	14	7	79
(Wabash River Valley)	1	24	1	12	16	21	0	0	49	0	0	0	—	—	—
Petersburg Silt	—	—	5	3	11	18	1	4	48	2	1	3	—	—	—
TILL															
Wedron Formation															
Wadsworth Till Member	4	7	1	1	8	16	0	2	68	1	1	2	21	8	71
Haeger Till Member	2	11	0	1	8	20	0	0	54	8	5	4	22	9	69
Yorkville Till Member	6	11	1	1	7	15	1	tr.	64	2	6	3	20	10	70
Malden Till Member	8	7	1	2	11	13	0	1	66	1	2	3	19	9	72
Tiskilwa Till Member	7	14	1	2	14	16	tr.	0	60	2	3	2	20	7	73
Delavan Till Member	5	21	1	1	14	11	0	tr.	67	1	3	2	17	8	75
Esmond Till Member	3	9	2	1	13	18	0	2	60	tr.	3	1	18	6	76
Lee Center Till Member	1	8	0	1	10	12	0	2	60	1	0	14	19	11	70
Winnebago Formation															
Capron Member	1	8	1	2	14	23	0	1	54	0	2	3	19	7	74
Argyle Till Member	6	8	2	1	13	19	tr.	tr.	60	1	2	2	17	5	78
Glasford Formation															
(SE—undifferentiated)	11	11	3	3	22	9	tr.	1	56	1	1	4	15	10	75
Radnor Till Member	7	10	3	2	10	8	tr.	1	69	1	2	4	15	8	77
Hulick Till Member	12	9	3	3	13	14	0	1	59	1	2	4	14	7	79
Kellerville Till Member	11	17	5	3	17	15	1	1	52	tr.	1	5	13	9	78
Winslow Till Member	4	14	2	1	11	19	0	1	61	1	4	2	16	11	73
Ogle Till Member	1	24	2	0	10	9	0	0	79	0	0	0	18	9	73

TABLE 4—Continued

Rock-stratigraphic unit and geographic region	Number of samples	Black opaque (%)	Translucent heavy minerals (%): Tourmaline	Zircon	Garnet	Epidote	Staurolite	Actinolite	Hornblende	Enstatite	Hypersthene	Diopside, augite and other	Light minerals (%): K feldspar	Na-Ca feldspar	Quartz and other
TILL—Continued															
Banner Formation															
(eastern)	4	11	1	1	21	5	0	1	58	1	5	7	10	10	80
(western)	17	14	4	4	10	23	2	1	50	1	1	4	12	8	80
Enion Formation	3	16	1	1	9	18	3	0	65	tr.	tr.	1	13	8	79
SAND AND GRAVEL															
Henry Formation															
(Upper Miss. River Valley)	6	20	1	2	15	37	tr.	1	36	1	1	1	6	8	76
(Rock River Valley)	6	30	1	2	16	13	0	1	52	2	2	5	17	11	72
(Illinois River Valley)	26	15	2	3	16	15	tr.	1	51	1	3	2	16	9	75
(NW Illinois)	3	29	1	2	19	13	0	0	53	0	0	11	21	13	66
Grover Gravel	5	58	19	60	2	5	5	0	1	0	0	8	—	—	—
Mounds Gravel	3	18	11	36	3	2	23	0	0	0	0	25	—	—	—

TABLE 5—SELECTED ANALYSES FROM STRATIGRAPHIC SECTIONS DESCRIBED IN TABLE 6

(X-ray analyses by H. D. Glass, Illinois State Geological Survey)

Stratigraphic section (see table 6 for location, position, and description)	Sample no.	Clay mineral composition $<2\mu$ fraction (%)			Carbonate minerals $<2\mu$ fraction (counts/sec)		Matrix grain-size of tills (%)		
		Expand-able clay minerals	Illite	Kao-linite and chlorite	Cal-cite	Dolo-mite	Sand	Silt	Clay
RICHLAND LOESS									
Malden South..........	P-6869	78	15	7	0	0			
MORTON LOESS									
Campbells Hump.......	P- 547	76	12	12	0	5			
Campbells Hump.......	548	73	16	11	0	10			
Farm Creek............	1481	46	30	24	0	12			
Farm Creek............	1482	47	30	23	0	13			
Farm Creek............	1483	53	26	21	0	23			
Farm Creek............	1484	52	27	21	0	22			
Farm Creek............	1485	47	30	23	0	14			
Farm Creek............	1486	49	30	21	0	32			
Malden South..........	6862	56	28	16	0	15			
Malden South..........	6861	71	18	11	10	16			
PEORIA LOESS									
Chapin................	P-2123	68	22	10	0	13			
Chapin................	2124	73	18	9	0	8			
Chapin................	2125	73	18	9	0	0			
Chapin................	2126	69	21	10	0	0			
Cottonwood School......	106	55	28	17	0	11			
Cottonwood School......	107	53	33	14	0	25			
Cottonwood School......	108	57	28	15	0	15			
Cottonwood School......	109	45	39	16	0	14			
Cottonwood School......	110	45	39	16	0	15			
Flat Rock..............	1160	28	55	17	0	0			
Gale..................	469	61	25	14	0	10			
Gale..................	470	66	74	10	0	11			
Gale..................	471	73	20	7	0	8			
Gale..................	472	76	16	8	0	7			
Gale..................	473	80	15	5	0	5			
Jubilee College.........	1931	72	18	10	0	13			
Jubilee College.........	1932	73	18	9	0	20			
Jubilee College.........	1933	72	16	12	0	10			
Jubilee College.........	1934	72	16	12	0	15			
Jubilee College.........	1935	72	16	12	0	14			
Jubilee College.........	1936	61	26	13	0	8			
Jubilee College.........	1937	70	18	12	0	0			
New Salem NE.........	6750	71	21	8	0	0			
Pleasant Grove School...	2255	68	25	7	0	11			
Pleasant Grove School...	2256	64	28	8	6	14			

TABLE 5—Continued

Stratigraphic section (see table 6 for location, position, and description)	Sample no.	Clay mineral composition <2μ fraction (%)			Carbonate minerals <2μ fraction (counts/sec)		Matrix grain-size of tills (%)		
		Expandable clay minerals	Illite	Kaolinite and chlorite	Calcite	Dolomite	Sand	Silt	Clay
Pleasant Grove School...	2257	64	26	10	5	10			
Pleasant Grove School...	2259	60	28	12	11	9			
Pleasant Grove School...	2262	62	26	12	22	8			
Pleasant Grove School...	2265	64	27	9	19	7			
Pleasant Grove School...	2268	64	27	9	10	6			
Pleasant Grove School...	11	60	20	20	31	13			
Pulleys Mill............	2525	70	20	10	0	0			
Zion Church............	1980	63	21	16	0	0			
Zion Church............	1981	71	20	9	0	22			
Zion Church............	1982	72	15	13	0	17			
ROBEIN SILT									
Campbells Hump.......	P- 545	72	12	16	0	0			
Campbells Hump.......	546	72	9	19	0	0			
Farm Creek............	1477	65	9	26	0	0			
Farm Creek............	1478	64	10	26	0	0			
Farm Creek............	1479	77	9	14	0	0			
Farm Creek............	1480	75	8	17	0	0			
Wedron................	489	12	38	50	19	10			
Wedron................	491	9	65	26	25	55			
Wedron................	493	11	63	26	40	70			
ROXANA SILT									
Farm Creek............	P-1474	46	15	39	0	0			
Farm Creek............	1475	54	8	38	0	0			
Farm Creek............	1476	50	8	42	0	0			
MARKHAM SILT MEMBER—ROXANA SILT									
Chapin................	P-2112	54	21	25	0	0			
Chapin................	2113	55	19	26	0	0			
Gale..................	460	61	18	21	0	0			
McDONOUGH LOESS MEMBER—ROXANA SILT									
Chapin................	P-2114	59	20	21	0	0			
Chapin................	2115	59	18	23	0	0			
Chapin................	2116	60	20	20	0	0			
Cottonwood School.....	99	71	15	14	0	0			
Gale..................	461	76	12	12	0	0			
Gale..................	462	69	13	18	0	0			
Pleasant Grove School...	8A	70	17	13	0	0			
Pleasant Grove School...	8AA	72	13	15	14	0			
Pleasant Grove School...	8B	72	13	15	36	7			
Pleasant Grove School...	8BB	63	22	15	8	0			

(Continued on next page)

TABLE 5—Continued

Stratigraphic section (see table 6 for location, position, and description)	Sample no.	Clay mineral composition <2μ fraction (%)			Carbonate minerals <2μ fraction (counts/sec)		Matrix grain-size of tills (%)		
		Expandable clay minerals	Illite	Kaolinite and chlorite	Calcite	Dolomite	Sand	Silt	Clay
MEADOW LOESS MEMBER—ROXANA SILT									
Chapin	P-2117	70	13	17	0	0			
Chapin	2118	72	12	16	0	0			
Chapin	2119	72	11	17	0	0			
Chapin	2120	73	9	18	0	0			
Chapin	2121	77	10	13	0	0			
Cottonwood School	100	60	22	18	0	0			
Cottonwood School	101	71	16	13	0	17			
Cottonwood School	103	87	6	7	0	7			
Cottonwood School	104	77	11	12	0	15			
Gale	463	68	14	18	0	0			
Gale	464	72	15	13	0	14			
Gale	465	69	18	13	0	7			
Gale	466	73	14	13	0	7			
Gale	467	58	27	15	0	0			
Gale	468	61	23	16	0	0			
Jubilee College	1927	62	13	26	0	0			
Jubilee College	1928	70	9	21	0	0			
Jubilee College	1929	72	10	18	0	0			
Jubilee College	1930	70	13	17	8	7			
Pleasant Grove School	8	52	27	21	0	15			
Pleasant Grove School*	9	42	25	33	20	26			
Pleasant Grove School	10	63	18	19	72	15			
Pleasant Grove School	10A	67	18	15	7	22			
Pleasant Grove School	12	52	27	21	0	0			
DELAVAN TILL MEMBER—WEDRON FORMATION									
Farm Creek	P-1487	11	67	22	15	15			
LEE CENTER TILL MEMBER—WEDRON FORMATION									
Malden South	P-6863	10	77	13	20	29	29	39	32
Malden South	6864	18	67	15	24	50			
Wedron	495	6	75	19	17	38	57	32	11
Wedron	2075	8	68	24	15	25			
MALDEN TILL MEMBER—WEDRON FORMATION									
Malden South	P-6867	8	77	15	30	50	20	38	42
Malden South	6868	13	77	10	23	42			
Wedron†	2077	4	76	20	30	43			
Wedron‡	2078	3	73	24	15	27			
Wedron	2079	3	74	23	20	24			
Wedron	2080	6	72	22	16	36			
Wedron	2082	10	78	12	12	30			

* Sand. † Silt. ‡ Clay.

TABLE 5—Continued

Stratigraphic section (see table 6 for location, position, and description)	Sample no.	Clay mineral composition $<2\mu$ fraction (%)			Carbonate minerals $<2\mu$ fraction (counts/sec)		Matrix grain-size of tills (%)		
		Expandable clay minerals	Illite	Kaolinite and chlorite	Calcite	Dolomite	Sand	Silt	Clay
TISKILWA TILL MEMBER—WEDRON FORMATION									
Malden South	P-6865	19	65	16	32	53			
Malden South	6866	20	64	16	34	36	30	36	34
Wedron	496	6	64	30	40	50	29	34	37
Wedron	2076	6	64	30	20	37			
GLASFORD FORMATION (UNDIFFERENTIATED)									
Campbells Hump	P- 542	6	66	28	0	0	33	33	34
Flat Rock	1157	15	53	32	0	0			
Pulleys Mill	2519	49	36	15	23	6			
Pulleys Mill	2520	47	38	15	0	0			
BERRY CLAY MEMBER—GLASFORD FORMATION									
Rochester	P- 769	74	19	7	0	0			
Rochester	770	73	21	6	0	0			
Rochester	773	75	18	7	0	0			
Rochester	774	82	10	8	0	0			
DUNCAN MILLS MEMBER—GLASFORD FORMATION									
Cottonwood School	P- 96	68	19	13	0	0			
Lewistown	6638	77	14	9	0	0			
Lewistown	6693	68	17	15	0	0			
Lewistown	6694	50	41	9	0	0			
Lewistown	6695	68	15	17	0	0			
HULICK TILL MEMBER—GLASFORD FORMATION									
Chapin	P-6648	14	63	23	21	29	22	50	28
Chapin	6649	12	66	22	27	27			
Chapin	6650	10	70	20	21	33			
Chapin	6651	13	67	20	26	28			
Chapin	6652	13	64	23	26	37			
Cottonwood School	97	33	54	13	0	28	47	29	24
Enion	6738	25	59	16	0	0			
Enion	6739	34	52	14	0	0			
Lewistown	6639	15	64	21	17	7	30	50	20
Lewistown	6696	16	61	23	26	16	36	42	22
Tindall School	6718	20	64	16	21	30	31	39	30
Tindall School	6719	20	64	16	17	20	39	37	24
Toulon	6835	27	48	25	12	16	25	46	29
Toulon*	6836	34	44	22	16	20			
Toulon	6837	26	48	26	13	18	21	50	29

* Sand.

(Continued on next page)

TABLE 5—Continued

Stratigraphic section (see table 6 for location, position, and description)	Sample no.	Clay mineral composition $<2\mu$ fraction (%)			Carbonate minerals $<2\mu$ fraction (counts/sec)		Matrix grain-size of tills (%)		
		Expandable clay minerals	Illite	Kaolinite and chlorite	Calcite	Dolomite	Sand	Silt	Clay
KELLERVILLE TILL MEMBER—GLASFORD FORMATION									
Cottonwood School......	P- 95	51	31	18	0	0			
Enion..................	6724	30	54	16	16	17			
Enion..................	6725	25	54	21	22	26			
Enion..................	6730	17	56	27	22	22	44	34	22
Enion..................	6735	17	56	27	31	25	37	41	22
Enion..................	6731	17	56	27	30	24			
Lewistown.............	6636	21	61	18	7	13			
Lewistown.............	6637	44	40	16	0	0			
Lewistown.............	6690	13	66	21	11	18			
Lewistown.............	6691	11	67	22	12	14	31	44	25
Lewistown.............	6692	21	56	23	0	10			
New Salem NE.........	1712	53	29	18	0	0	23	49	28
New Salem NE.........	6751	51	32	17	0	20			
Petersburg.............	94	24	62	14	15	22	34	48	18
Pleasant Grove School...	1	36	51	13	28	32			
Pleasant Grove School...	1A	22	58	20	17	31	36	40	24
Pleasant Grove School...	1488	35	54	11	0	0			
Pleasant Grove School...	1490	38	50	12	0	0			
Pleasant Grove School...	1492	39	46	15	0	0			
Pleasant Grove School...	1494	44	42	14	0	0			
Tindall School..........	125	37	46	17	27	19			
Washington Grove......	1974	38	44	18	8	10			
RADNOR TILL MEMBER—GLASFORD FORMATION									
Farm Creek............	P-1472	2	69	29	14	25			
Jubilee College.........	1922	8	78	14	14	22			
Jubilee College.........	1923	7	73	20	18	21			
Jubilee College.........	1924	9	67	24	16	31			
Jubilee College.........	6830	14	70	16	15	30			
Jubilee College.........	6831	7	80	13	20	37	26	46	28
Jubilee College.........	6832	11	74	15	14	26	19	49	32
Jubilee College.........	6833	16	66	18	14	10	23	49	28
Jubilee College.........	6834	14	67	19	5	15			
Tindall School..........	6720	9	79	12	12	22	29	46	25
Toulon................	6839	8	84	8	9	18	15	55	30
Toulon................	6840	16	76	8	9	27	19	51	30
TOULON MEMBER—GLASFORD FORMATION									
Farm Creek............	P-1471	4	71	25	30	36			
Jubilee College.........	1921	35	44	20	0	16			
Jubilee College.........	6826	29	51	20	0	0			
Jubilee College.........	6827	65	23	12	7	9			
Jubilee College.........	6828	6	68	26	6	55			
Toulon................	6838	7	72	21	0	11			

TABLE 5—Continued

Stratigraphic section (see table 6 for location, position, and description)	Sample no.	Clay mineral composition $<2\mu$ fraction (%)			Carbonate minerals $<2\mu$ fraction (counts/sec)		Matrix grain-size of tills (%)		
		Expandable clay minerals	Illite	Kaolinite and chlorite	Calcite	Dolomite	Sand	Silt	Clay
LOVELAND SILT									
Washington Grove......	P-1974B	25	59	16					
Washington Grove......	1974C	25	53	22					
Zion Church............	2089	65	11	24	0	0			
PEARL FORMATION									
Lewistown.............	P-6697	16	58	26	14	20			
PETERSBURG SILT									
Petersburg.............	P- 90	56	32	12	0	14			
Petersburg.............	91	47	43	10	50	12			
Washington Grove......	1974A	38	43	19					
TENERIFFE SILT									
Lewistown.............	P-6698	26	55	19	13	26			
Pleasant Grove School...	4	77	13	10	0	0			
Pleasant Grove School...	7	58	29	13	0	23			
BANNER FORMATION									
Enion..................	P-6728	80	13	7	14	0	23	57	20
Enion..................	6729	20	34	46	13	0	30	31	39
Tindall School..........	119	36	40	24	22	27			
Tindall School..........	119A	49	30	21	25	30	24	49	27
Tindall School..........	120	39	44	17	23	27			
Tindall School†.........	121	26	48	26	22	13			
Tindall School†.........	121A	28	43	29	18	20			
Tindall School..........	123	45	40	15	19	25	28	46	26
Tindall School..........	123A	45	41	14	14	22			
Zion Church............	1746	69	11	20	16	0			
HARKNESS SILT MEMBER—BANNER FORMATION									
Zion Church............	P-1745	78	10	12	12	7			
LIERLE CLAY MEMBER—BANNER FORMATION									
Zion Church............	P-2088	61	14	25	0	0			
ENION FORMATION									
Enion..................	P-6726	59	31	10	0	0	29	43	28
Enion..................	6727	62	24	14	0	0	30	31	39

† Silt.

TABLE 6—STRATIGRAPHIC SECTIONS

The following 21 stratigraphic sections describe exposures in Illinois and illustrate many of the aspects of Pleistocene stratigraphy. These sections contain the type localities for 21 rock-stratigraphic units, 4 soil-stratigraphic units, and 3 time-stratigraphic units and include paratypes for several other units. The sample numbers preceded by "P" are the numbers used in the Illinois State Geological Survey collections. Analytical data on many of these samples are on file at the Survey. The sections are arranged alphabetically by name. Table 7 lists 414 previously published described stratigraphic sections from 78 Illinois counties.

CACHE SECTION

Measured in inactive gravel pit in the SW SW SW Sec. 7, T. 16 S., R. 1 W., 2 miles north of Cache, Pulaski County, Illinois, 1948, 1960.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
5. Loess, leached, tan-brown, fine grained; Modern Soil in top	16.0
Altonian Substage	
Roxana Silt	
4. Silt, leached, brown to purplish brown, clayey, massive; Farmdale Soil in top	5.0
Illinoian Stage	
Loveland Silt	
3. Colluvium, silt with sand and some pebbles in the lower part, red-brown, clayey, compact; Sangamon Soil	4.0
Pliocene-Pleistocene Series	
Mounds Gravel (type section)	
2. Gravel with some sand and silt; pebbles predominantly chert, brown, subrounded, interbedded in middle and lower part with thin beds of sand and silty fine sand; leached throughout; upper part contains irregular zones cemented with dark brown to black limonite; clayey in upper part but moderately loose in middle and lower parts; Yarmouth Soil in top	18.0
Eocene Series	
Wilcox Formation	
1. Sand, medium to coarse, bedded, white, locally streaked with tan	4.0
Total	47.0

CAMPBELLS HUMP SECTION

Measured in creek bank exposure in NW NE SE Sec. 15, T. 21 N., R. 1 E., De Witt County, Illinois, 1959.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Wedron Formation	
6. Till, calcareous, gray, blocky, tough (P-549 base)	5.0
Morton Loess	
5. Loess, calcareous, tan to yellow-tan, massive; sparse fragments of fossil snail shells; carbonaceous flecks in lower part (P-548 upper; P-547 lower)	3.0
Farmdalian Substage	
Robein Silt	
4. Silt, leached, reddish chocolate, grading downward through speckled brown to tan-brown with rusty streaks; truncated Farmdale Soil (P-546 upper; P-545 lower)	3.0
Altonian Substage	
Roxana Silt	
Markham Silt Member	
3. Colluvium, sandy silt with a few dispersed pebbles, leached, tan-brown and mottled with gray-tan, massive; Chapin Soil (P-544)	1.5
Illinoian Stage	
Jubileean Substage	
Glasford Formation	
2. Till, red-brown, clayey, leached, tough, sandy, pebbly; Sangamon Soil (P-543)	3.0
1. Till, leached, blue-green, interzoned with tan in upper part, sandy, massive (P-542)	4.0
Total	19.5

CHAPIN SECTION

Measured in roadcuts (Illinois Highway 104) in NW SE NE Sec. 8, T. 15 N., R. 11 W., Morgan County, Illinois, 1965, 1969.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

10. Loess, leached, massive, mottled tan and gray, light brown to light tan in upper part; surface soil A-zone gray and platy; B-zone light brown and clayey (P-2125 base; P-2126 2 feet above base; P-2127 B_3-zone 4 feet above base; P-2128 B_2-zone 6 feet above base; P-2129 B_1-zone 9 feet above base) 10.0

9. Loess, calcareous, massive, mottled tan and gray; sharp contact with leached loess above but gradational at base (P-2123 base; P-2124 top) 1.0

8. Loess, very weakly calcareous, massive, light tan-brown (P-2122 middle) 0.5

Altonian Substage
Roxana Silt
Meadow Loess Member

7. Loess, coarse silt, massive, leached, pinkish brown but more reddish at top and bottom, more clayey at top; truncated Farmdale Soil in top (P-2117 to P-2121 upward at 1-foot intervals) 5.5

McDonough Loess Member

6. Silt with fine sand, leached, gray-tan; very few dispersed small pebbles and sparse small Mn-Fe pellets; Pleasant Grove Soil (P-2114 to P-2116 upward at 6-inch intervals) 1.5

Markham Silt Member (type section)

5. Silt and sand, leached gray-tan to light gray-brown; small pebbles dispersed throughout; small Mn-Fe pellets; gradational contacts; Chapin Soil (type section) (P-2112 base; P-2113 1 foot above base) ... 1.5

Illinoian Stage
Monican Substage
Glasford Formation
Hulick Till Member

4. Till, leached massive to indistinctly blocky, tan, yellow-tan and rusty brown; Sangamon Soil (paratype; also paratype for Sangamonian Stage); lowermost 2 feet in C-zone of soil; from 2 feet above base grades upward to B_3-zone; splotches of red-brown become more common upward; clay skins and Mn-Fe pellets increase upward; indistinctly blocky to microblocky; B_2-zone from 4 to 6 feet above base, red-brown, clayey; small Mn-Fe pellets and staining on joint surfaces; top 6 inches in A-zone or B_1-zone of Sangamon Soil, contains fewer Mn-Fe pellets, less red in color and more sandy and friable than B_2-zone below, structureless (P-2104 to P-2111 from base upward at 1-foot intervals) 6.5

3. Till, tan-brown, weakly calcareous at top (dolomite zone) to strongly calcareous downward, massive to blocky (P-2101 base; P-6653 6 inches above base; P-2102 4 feet above base; P-2103 top 6 inches) .. 5.0

2. Till, gray to blue-gray, calcareous, tough, jointed with brown oxidized rinds along joints and some caliche along joint planes; contact at top with oxidized zone irregular (P-6652 1 foot below top; P-6651 4 feet below top; P-6650 6 feet below top; P-6649 8 feet below top; P-6648 11 feet below top) 33.0

Pennsylvanian System

1. Shale, poorly exposed to level of creek channel near end of highway bridge 15.0

Total 79.5

COTTONWOOD SCHOOL SECTION

Measured in roadcuts at center E. line Sec. 11, T. 18 N., R. 11 W., Cass County, Illinois, 1958, 1959, 1961, 1964.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage (paratype)
Woodfordian Substage (paratype)
Peoria Loess

10. Loess, coarse, gray-tan to pale yellow-tan; massive to indistinctly bedded and laminated; calcareous except in Modern Soil at top; sparsely fossiliferous in middle and lower part; contains Jules Soil in the upper part (P-110) 25.0

9. Loess, coarse to medium, gray-tan, massive, calcareous; indistinct

streaks of pale pink throughout; contains fossil snails (P-109 to P-106 downward) 15.0

Altonian Substage
Roxana Silt
Meadow Loess Member

8. Loess, coarse, massive, dark pink in lower part grading upward to pink-gray, leached in upper part, weakly calcareous in lower part; sharp contact at top, gradational at base; truncated Farmdale Soil at top; (P-105 upper; P-104 lower)...... 15.0
7. Loess, medium, gray, massive, weakly calcareous; contains limonite tubules throughout (P-103 upper; P-102 lower) 10.0
6. Loess, medium, pink-tan, massive, weakly calcareous, nonfossiliferous; sharp contact at base, gradational at top; contains some limonite tubules and calcium carbonate concretions (P-100 lower; P-101 upper) 8.0

McDonough Loess Member

5. Silt, gray mottled with tan, leached, clayey; contains some sand and dispersed small chert pebbles; truncated Pleasant Grove Soil at top (P-99) 4.0

Markham Silt Member

4. Silt, clay, sand, and chert fragments, massive, compact, leached, brown; Chapin Soil 1.0

Illinoian Stage
Monican Substage
Glasford Formation
Hulick Till Member

3. Till, pebbly, cobbly, and, below soil, gray, compact, and calcareous at base; Sangamon Soil in top; thin A-zone above strongly developed, red-brown, clayey B-zone 2 to 2.5 feet thick (P-98 from B-zone; P-97 lower) 8.0

Duncan Mills Member

2. Silt, gray banded with tan, compact, blocky, calcareous; contains some sand and a few small pebbles (P-96) 3.0

Liman Substage
Glasford Formation (continued)
Kellerville Till Member

1. Till, gray to gray-brown, leached, massive, compact, pebbly; truncated Pike Soil in top; rests on shale and siltstone of Pennsylvanian age (P-95) 5.0

Total 94.0

ENION SECTION

Measured in creek bank exposures in NW SW SE Sec. 32, T. 4 N., R. 3 E., Fulton County, Illinois, 1969.

Thickness (ft)

Pleistocene Series
Illinoian Stage
Jubileean Substage
Teneriffe Silt

10. Silt, leached, compact, blocky, gray becoming brown in upper part; truncated Sangamon Soil (P-6740 1 foot above base) 10.0

Monican Substage
Glasford Formation
Hulick Till Member

9. Till, leached, compact, tan, silty, red-brown at base; very few pebbles (P-6739 top; P-6738 base).... 2.0

Duncan Mills Member (type section)

8. Sand and fine gravel interbedded with sand and silt, leached, gray-tan; contorted bedding; truncated Pike Soil (P-6737 top) 3.0
7. Sand, grading downward to sand and gravel, leached, tan to gray-tan at top grading downward to tan-brown (P-6736 lower) 15.0

Liman Substage
Glasford Formation (continued)
Kellerville Till Member

6. Till, calcareous, pebbly, blue-gray, platy in upper part with discontinuous streaks of sand and gravel, tan-brown (P-6731 base) 7.0
5. Till, calcareous, massive, compact, pebbly (P-6725, P-6730, P-6735).. 4.0
4. Till, dense, calcareous, compact, reddish brown; rust-brown iron zone at top, sharp contact at base (P-6724) 1.0

Kansan Stage
Banner Formation

3. Sand, silt, and gravel, leached, tough, compact, purple-brown at top grading downward through dark rusty brown to tan-brown; reddish brown streaks throughout; bedded lower part; truncated Yarmouth Soil (P-6734, P-6723 top; P-6733 2 feet below top; P-6732 5 feet below top) 15.0
2. Till, calcareous, compact, massive, gray, silty and sandy; concentration of cobbles and boulders in base; sharp contact at base (P-6728 lower part; P-6729 upper part) 7.0

Nebraskan Stage
Enion Formation (type section)

1. Sand and gravel, leached, massive to indistinctly bedded, tan to rusty brown; contains boulders of till, leached, rusty tan, compact, massive; truncated Afton Soil at top; base at bottom of creek channel (P-6726 from till boulder; P-6727 upper part) 3.0

Total 67.0

FARM CREEK SECTION

Described by Leverett, 1899a; Leighton, 1926b, p. 5; 1931. Measured in creek bank exposure in NE SW SE Sec. 30, T. 26 N., R. 3 W., Tazewell County, Illinois, 1959, 1962.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Richland Loess

11. Loess, gray to tan-brown, leached but locally weakly calcareous in basal part, massive; Modern Soil in top; sharp contact on calcareous till at base 6.0

Wedron Formation
Delavan Till Member
Shelbyville Drift

10. Till, calcareous, gray to blue-gray, compact, massive (P-1487 base) 30.0

Morton Loess

9. Loess, calcareous, gray to gray-tan, tough, compact, massive; contains dispersed fossil snail shells, generally crushed and fragmented; at a few places a thin zone of organic material, including moss, at upper contact, radiocarbon dated 20,340 ± 750 (W-349); wood from 6 inches below top dated 20,700 ± 650 (W-399) (P-1486 to P-1481 from top downward) 6.0

Farmdalian Substage (type section)
Robein Silt (type section)

8. Silt, leached, organic-rich with flakes of charcoal, brown, compact, tough; indistinct bedding or lamination in upper part, grading downward to massive silt; Farmdale Soil (type section) (radiocarbon dates of 22,900 ± 900 (W-68) from upper 1 foot; 25,100 ± 800 (W-69) from 3 to 4 feet below top) (P-1480 to P-1477 from top downward) 4.5

Altonian Substage
Roxana Silt

7. Silt, sandy, massive, compact, gray with some streaks and mottles of tan and rusty brown; contains dispersed small pebbles, more abundant in lower part (P-1476 to P-1474 from top downward) 3.5

Illinoian Stage
Jubileean Substage
Glasford Formation
Radnor Till Member

6. Till, leached, brown with some streaks and splotches of red-brown, tough, clayey; Sangamon Soil; B_2-zone of soil thinner than typical for Sangamon Soil of the region (P-1473 top; P-482B 2.5 feet below top; P-482A 5.5 feet below top) 6.0
5. Till, calcareous, blue-gray, massive, pebbly, compact (P-1472 base)... 8.5

Toulon Member

4. Sand, medium, calcareous, yellow-brown, loose 0.5
3. Silt, calcareous, laminated, gray, continuous throughout exposure (P-1471) 0.5
2. Sand, fine gravel, and some silt, calcareous, brown 0.5

Monican Substage
Glasford Formation (continued)
Hulick Till Member

1. Till, calcareous, blue-gray, pebbly, bouldery, massive, compact; at top a zone 1 foot thick is reddish brown to purple directly below the overlying sand and gravel but does not show soil characteristics (P-1470 2 feet below top) 25.0

Total 91.0

FLAT ROCK SECTION

Measured in roadcut in SW NE SW Sec. 6, T. 5 N., R. 11 W., Crawford County, Illinois, 1961.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

4. Loess, leached, fine grained, tan-brown, compact, massive; Modern Soil in top (P-1160 middle) 4.0

Altonian Substage
Roxana Silt
Markham Silt Member

3. Colluvium of silt, sand, and some

pebbles, leached, clayey, tan-brown to reddish tan-brown; Chapin Soil (P-1159) 1.0

Illinoian Stage
Glasford Formation

2. Till; Sangamon Soil; B-zone, red-brown, microblocky; contains clay skins and Mn-Fe pellets (P-1158) .. 3.0
1. Till, leached, yellow-tan mottled with gray and brown, massive, compact, jointed (P-1157 lower) 4.0

Total 12.0

GALE SECTION

Measured in borrow pit, cen. Sec. 33, T. 14 S., R. 3 W., Alexander County, Illinois, 1955, 1959.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

8. Loess, gray, massive, friable, calcareous below thin Modern Soil at top; contains sparse fauna of fossil snail shells (P-469 to P-473 from base upward) 25.0

Altonian Substage
Roxana Silt
Meadow Loess Member

7. Loess, leached, pale pink, massive; truncated Farmdale Soil at top (P-467 middle; P-468 top) 6.0
6. Loess, calcareous, gray, massive; contains fossil snail shells throughout; radiocarbon date of 37,000 ± 1,500 (W-869) from lower part (P-465 lower; P-466 top) 8.0
5. Loess, weakly calcareous, pink, massive, compact; contains fossil snail shells sparsely throughout (P-463 lower; P-464 upper) 7.0

McDonough Loess Member

4. Loess, leached, coarse, massive, gray-brown; contains abundant large concretions of $CaCO_3$; Pleasant Grove Soil (P-461, P-462) 4.0

Markham Silt Member

3. Silt and clay with some sand and a few small pebbles, leached, pinkish tan-brown, tough, compact; Chapin Soil (P-460) 2.0

Illinoian Stage
Loveland Silt

2. Silt and clay, with some sand and a few small chert fragments, leached, tough, compact, reddish brown in upper part grading downward to gray and brown mottled with yellow-tan; Sangamon Soil (P-458 lower; P-459 top) 3.0

Pre-Illinoian
Mounds Gravel

1. Gravel, sand, and silt, leached, brown, compact; gravel largely of rounded to angular chert ranging from brown to variegated; truncated Yarmouth Soil in top; base rests on Thebes Sandstone 2.0

Total 57.0

JUBILEE COLLEGE SECTION

Measured in roadcuts and auger boring in SW SW SW Sec. 7, T. 10 N., R. 7 E., Peoria County, Illinois, 1964, 1965, 1969.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

9. Loess, massive; upper half leached; tan - brown grading downward through a mottled zone to gray in lower part; Modern Soil in upper half with caliche nodules at the base of the leached loess; lower half calcareous (Sample P-1932 6 inches above base; P-1933 1.5 feet above; P-1934 2.5 feet above; P-1935 3.5 feet above; P-1936 4.5 feet above; P-1937 6.5 feet above) 10.0
8. Loess, massive, weakly calcareous in upper part, gray streaked with rusty brown; contains small Mn-Fe pellets (P-1931) 1.0

Altonian Substage
Roxana Silt
Meadow Loess Member

7. Loess, massive, leached, tan to light brown with a purple-tan zone at top; truncated Farmdale Soil; contains some small Mn-Fe pellets (P-1927 1 foot above base; P-1928 2 feet above; P-1929 3 feet above; P-1930 4 feet above) 4.0

Markham Silt Member

6. Silt, with some fine sand and clay, massive, leached, gray-brown; Chapin Soil; contains some Mn-Fe pellets (P-1926) 0.5

Illinoian Stage
Jubileean Substage (type section)
Glasford Formation
Radnor Till Member (type section)

5. Till; Sangamon Soil; B-zone 2 feet

thick, clayey, microblocky to indistinct columnar structure, mahogany-brown, micromottled with black Mn-Fe pellets, clay skins; some concentration of pebbles at base of B-zone suggests an incipient "stone-line"; CL-zone below B-zone is massive, gray-tan to light brown and contains sparse caliche nodules (P-1925 from B-zone) 4.0

4. Till, massive, calcareous, blue-gray, cobbly, bouldery, well jointed with oxidized rinds along joints (P-6829 6 inches above base; P-1922 1 foot above; P-6830 2 feet above; P-6831 4 feet above; P-1923, P-6832 8 feet above; P-1924, P-6833, P-6834 12 feet above) 18.0

Toulon Member

3. Silt with some sand, massive, calcareous, gray to light tan; some jointing; locally cemented at top; pinches out toward north (P-6827 base; P-1921 middle; P-6828 top) 3.0

Monican Substage (type section)
Toulon Member (continued)

2. Sand, silt, sandy silt, pebbly sandy clayey silt; occupies a channel cut in till below and pinches out to north; irregularly bedded; locally leached and strongly oxidized in upper part, but elsewhere calcareous, tan, gray-tan, and rusty brown (P-1919, P-1920, P-6826 top; P-6825, P-1918 4.5 feet below top; P-1917 7 feet below top).......... 8.0

Hulick Till Member

1. Till, massive, calcareous, gray; contains cobbles and boulders, and some joints (P-6817 base in auger boring; P-6818 1 foot up; P-6819 2 feet up; P-6820 3 feet up; P-6821 4 feet up; P-1872, P-1916A, P-6822 6 feet up; P-6823 8 feet up; P-6824 10 feet up; P-1916B 11 feet up).. 14.0

Total 62.5

LEWISTOWN SECTION

Measured in roadcuts in SW SE SE Sec. 21, T. 5 N., R. 3 E., Fulton County, Illinois, 1969.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage and Illinoian Stage

6. Partly covered; Peoria Loess on Roxana Silt on Sangamon Soil developed in Teneriffe Silt 8.0

Illinoian Stage
Jubileean Substage
Teneriffe Silt

5. Silt, vesicular, calcareous, platy to bedded, light tan to medium gray; contains abundant $CaCO_3$ concretions (P-6698 lower) 3.0

Pearl Formation

4. Sand, gravelly in upper part, tan, calcareous (P-6697 upper) 4.0

Monican Substage
Glasford Formation
Hulick Till Member (type section)

3. Till, calcareous, sandy, pebbly, loose, massive to platy, gray-tan; basal contact, though sharp, is contorted, suggesting glacial overriding (P-6696, P-6639) 3.0

Duncan Mills Member

2. Silt and clay with some fine sand, calcareous, irregularly bedded and locally distorted, gray, dark gray with red-brown clay zones at top and bottom (P-6693 base; P-6694 lower; P-6695 top; P-6638) 6.0

Liman Substage
Glasford Formation (continued)
Kellerville Till Member

1. Till, calcareous, silty, tan to gray-tan to yellow-tan, compact, blocky; lower part pebbly and contains large amounts of locally derived shale and siltstone (P-6690 lower; P-6691 middle; P-6692 upper; P-6636, P-6637) 9.5

Total 33.5

MALDEN SOUTH SECTION

Measured in roadcuts in SW SE SE Sec. 5, T. 16 N., R. 10 E., 2 miles south of Malden, Bureau County, Illinois, 1969.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Richland Loess

7. Loess, tan to tan-brown, leached, clayey; contains surface soil (P-6869 1 foot above base) 5.0

Henry Formation
Batavia Member

6. Sand and gravel, coarse and lenticular, tan-brown, weakly calcareous 2.0

Wedron Formation
Malden Till Member (type section)
Dover Drift

5. Till, sandy, silty, calcareous, tan-gray in lower part and tan-brown to brown in upper part, moderately compact (P-6867 1 foot above base; P-6868 8 feet above base) 15.0
4. Sand and gravel, moderately well sorted, calcareous, tan; sharp contact at base 10.0

Tiskilwa Till Member
Bloomington Drift

3. Till, silty, sandy, pink to pinkish brown, calcareous, compact; sharp contacts top and bottom (P-6865 1 foot above base; P-6866 5 feet above base) 8.0

Lee Center Till Member
Atkinson Drift

2. Till, sandy, silty, tan-gray, calcareous, compact (P-6863 1 foot above base; P-6864 4 feet above base) .. 4.5

Morton Loess

1. Loess, gray mottled with tan, grading to tan in upper part, calcareous, massive, compact (P-6861 3 feet below top; P-6862 top) 4.0

Total 48.5

NEW SALEM NORTHEAST SECTION

Measured in roadcut in NW NE SW Sec. 11, T. 4 S., R. 4 W., Pike County, Illinois, 1963, 1969.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

5. Loess, massive, leached, tan to light brown (P-6750 1 foot above base) 10.0

Altonian Substage
Roxana Silt

4. Silt, massive, clayey, leached, purple-brown; truncated Farmdale Soil in top; sharp contact at base (P-6748 3 inches above base; P-6749 6 inches below top) 5.0

Illinoian Stage
Jubileean and Monican Substages
Teneriffe Silt (type section)

3. Silt, sandy, leached, clayey in upper part, red to red-brown; small pebbles dispersed throughout; Sangamon Soil; B-zone of soil extends to base of unit; upper part has streaks and pods of fine gray sand and silt; somewhat more pebbly in base (P-6747 top; P-6746 middle; P-6745 base) 5.0

Liman Substage
Glasford Formation
Kellerville Till Member

2. Till, upper part leached, clayey, red-brown; becomes less clayey and tan-brown 4 feet below top; Pike Soil (type section); calcareous at 10 feet below top (P-6744 top; P-6743 1 foot below top; P-6742 2 feet below; P-6741 3 feet below; P-1712 10 feet below) 10.0
1. Till, calcareous, oxidized, massive, partly covered (P-6751 base).... 5.0

Total 35.0

PETERSBURG SECTION

Measured in roadcut, creek bank, and auger boring in NW NW NE Sec. 23, T. 18 N., R. 7 W., Menard County, Illinois, 1957, 1958, 1961.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

4. Loess, tan, massive, leached; Modern Soil in top 5.0

Illinoian Stage
Liman Substage
Glasford Formation
Kellerville Till Member

3. Till, massive, calcareous, compact, blue-gray, pebbly, cobbly; deeply truncated Sangamon Soil at top (P-94 2 feet above base) 20.0
2. Till, silty, massive, tan; contains fossil snails similar to those in the unit below and appears to be largely incorporated silt from the unit below (P-93 top; P-92 bottom) 2.0

Petersburg Silt (type section)

1. Silt, massive, compact, calcareous, gray-tan in upper part grading downward to purplish brown in lower part; contains fossil snails in upper half; lower half weakly calcareous and indistinctly laminated; auger boring penetrated Yarmouth Soil accretion-gley at base of section (P-1373X 1 foot below top; P-1372X 3 feet below top; P-1371X 5 feet below top; P-91 10 feet below top; P-90 16 feet below top)..... 20.0

Total 47.0

PLEASANT GROVE SCHOOL SECTION

Measured in borrow pits and access roadcuts in the SE Sec. 20, T. 3 N., R. 8 W., Madison County, Illinois, 1958, 1959, 1961, 1962, 1964, 1966; all elements of the section as described have not been exposed simultaneously.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
9. Loess, medium to coarse; loose and friable in upper part; calcareous except for very thin surface soil at top; light yellow-tan including some streaks and mottling of tan-brown and gray; contains several weakly developed A-C soils in upper part (P-2268 through P-2260 at 8-inch intervals downward from top; P-2259 1.5 feet lower; P-2258 through P-2255 downward at 3-foot intervals)	25.0
8. Loess, medium to coarse, massive, compact, calcareous, gray-tan to yellow-tan; contains fossil snail shells throughout; radiocarbon date from a quarter of a mile south determined on wood, 17,950 ± 550 (W-1055); radiocarbon date from 1 mile north determined on fossil snail shells, 17,100 ± 300 (W-730) (P 11 base)	15.0
Altonian Substage	
Roxana Silt (type section)	
Meadow Loess Member (type section)	
7. Loess, medium to coarse, massive, pink-tan, leached in upper part but weakly calcareous at base; truncated Farmdale Soil; sharp erosional contact at top but gradational at base (Zone IV in previous reports) (P-12 base)	11.0
6. Loess, medium to coarse, massive, gray-tan to gray, weakly calcareous throughout; contains fossil snail shells in lower part (Zone III in previous reports) (P-10A)	12.0
5. Loess, coarse, massive, pink-tan; contains fossil snail shells throughout; radiocarbon date on fossil snail shells from upper part of the unit, 35,200 ± 1,000 (W-729); in 1958 when face was at position of original bluff-line, a 1.5-foot bed of gray-tan fine to medium sand occurred in middle of unit (Zone II in previous reports); (P-10 7 feet below top; P-9 from middle bed of sand; P-8 base)	20.0
McDonough Loess Member (type section)	
4. Silt, coarse, massive, gray, weakly calcareous in middle with very sparse etched fragments of fossil snail shells; Pleasant Grove Soil (type section) at top; dark gray, organic-rich A-zone but no well differentiated B-zone; basal 6 inches may be A-zone of Chapin Soil resting directly on A-zone of Sangamon Soil below (Zone I in previous reports); contains a few "pods" of *Celtis occidentalis* (P-8B, P-8BB upper part; P-8A, P-8AA lower part)	5.0
Illinoian Stage	
Jubileean and Monican Substages	
Teneriffe Silt	
3. Silt, coarse, massive, leached; Sangamon Soil; A-zone tan-brown, granular, 8 inches thick; B_1-zone thin and gradational; B_2-zone red-brown, clayey, tough, columnar, 2 feet thick; gradational downward with B_3-zone, tan-brown becoming tan and gray-tan downward in the CL-zone, friable, massive; the basal 6 inches is weakly calcareous, gray, massive; 100 feet northward the silt thickens to 18 feet and rests on calcareous till where the Pike Soil has been removed from the till by erosion; (P-6B, A-zone of soil; P-6, P-6A, B_2-zone of soil; P-5, P-5A lower B_3-zone of soil; P-1497 1 foot above base where silt rests on Pike Soil; P-4, P-1496 6 inches above base where silt rests on Pike Soil; P-7 15 feet below top of unit 100 feet farther north where silt fills erosional low on the till surface)	10.5
Liman Substage	
Glasford Formation	
Kellerville Till Member	
2. Till, leached, gray-brown to tan-brown, massive; Pike Soil; little structure or clay accumulation in B-zone; some Mn-Fe staining and small pellets (P-1495 through P-1488 downward from top at 6-inch intervals)	4.0
1. Till, calcareous, tan to tan-gray, massive, pebbly, compact (P-1, P-1498 6 inches below top; P-1A lower part)	7.5
Total	110.0

PULLEYS MILL SECTION

Measured in roadcuts at center W line Sec. 28, T. 10 S., R. 2 E., Williamson County, Illinois, 1966.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
5. Loess; Modern Soil; A-zone 1 foot thick, gray, friable; B-zone 1.5 feet thick, clayey, massive, tan-brown (P-2526); B_3- and CL-zones, massive, leached, tan to light brown (P-2525 upper; P-2524 lower)	8.5
Altonian Substage	
Roxana Silt	
4. Silt, leached, massive, clayey, tan-brown; Farmdale Soil (P-2523)...	1.5
Illinoian Stage	
Liman Substage	
Glasford Formation	
3. Till; Sangamon Soil; A-zone in top 6 inches, friable, gray-tan, leached, massive (P-2522); B_2-zone, 2.5 feet, brown to reddish brown with bright red splotches, clayey, tough; contains Mn-Fe nodules, pellets, and splotches (P-2521)	3.0
2. Till; Sangamon Soil; B_3- and CL-zones; leached, tan to tan-brown, compact, sandy, silty (P-2520A upper)	4.0
1. Till, calcareous, gray, compact, jointed; extends to bottom of roadcut (P-2520 top; P-2519 base)...	1.5
Total	18.5

ROCHESTER SECTION

Measured in roadcuts in NW SE NW Sec. 34, T. 15 N., R. 4 W., Sangamon County, Illinois, 1960, 1962.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
6. Loess, leached, tan to tan-brown; Modern Soil in top; contains Mn-Fe pellets; clayey (P-776 base)......	7.0
Sangamonian Stage (paratype)	
Glasford Formation	
Berry Clay Member (type section)	
5. Accretion-gley (clay, sand, and silt), oxidized; contains some small pebbles, rusty tan grading downward to gray, tough, compact; Sangamon Soil (paratype); (Farmdale Soil developed in top of accretion-gley) (P-775)	0.5
4. Accretion-gley (clay, silt, and some sand), blue-gray to medium gray with some tan mottling, massive, tough, strongly fractured on desiccated surface; contains scattered fragments of chert and a few dispersed small pebbles; Sangamon Soil (P-774 to P-769 from top downward)	4.5
Illinoian Stage	
Monican Substage	
Glasford Formation (continued)	
Vandalia Till Member	
3. Till; Sangamon Soil; BG-zone; till, leached, gray-tan, massive, clayey, mottled with dark gray; thin zone of pebble concentrate at top (P-768, P-767)	0.5
2. Till; Sangamon Soil; CL-zone; till, leached, oxidized, pebbly, massive, tough (P-766, P-765)	1.5
1. Till, calcareous, blue-gray, silty, sandy, pebbly to cobbly, compact, jointed with oxidized rinds on joints; to bottom of road ditch (P-764 top; P-763 upper; P-762 lower)	5.0
Total	19.0

TINDALL SCHOOL SECTION

Measured in borrow pit in SW SW NE Sec. 31, T. 7 N., R. 6 E., Peoria County, Illinois, 1957, 1958, 1962, 1969.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess (type section)	
15. Loess, leached in top 5 feet, tan to gray streaked; rusty brown root tubules and color banding; Modern Soil in top; calcareous in lower part, tan-gray, massive	12.0
Farmdalian Substage and Altonian Substage	
Robein Silt and Roxana Silt	
14. Silt, leached in upper and lower parts, dark gray to black humic streaks, contorted by cryoturbations, light gray between humic streaks in upper part, rusty tan in lower part; contains iron concretions and tubules of limonite; cryoturbations prevent a sharp differentiation of Robein and Roxana Silts; Farmdale Soil in upper part	4.5

Altonian Substage
Roxana Silt
Markham Silt Member

13.	Silt and sand; dark gray to tan-gray, leached, massive; Chapin Soil	1.0

Illinoian Stage (paratype)
Jubileean Substage
Glasford Formation (type section)
Radnor Till Member

12.	Till; Sangamon Soil; gleyed in-situ profile, leached, dark gray to tan-gray, massive	4.0
11.	Till with network or "box work" of rusty brown iron-cemented and leached streaks and plates; blocks within iron-cemented streaks are gray calcareous till; Sangamon Soil ferretto zone (P-126)	2.0
10.	Till, calcareous, gray, tan, well jointed, gradational at top (P-6720)	3.0

Toulon Member

9.	Silt, with some sand, calcareous, tan to gray streaked with red; thin zones cemented with $CaCO_3$; zone pinches out southward and is replaced by a zone of oriented cobbles and boulders that suggest truncation by the overriding glacier	2.0

Monican Substage
Glasford Formation (continued)
Hulick Till Member

8.	Till, calcareous, oxidized, gray to light brown, compact, pebbly (P-6718, P-6719)	3.0
7.	Sand and gravel in discontinuous lenses; lenses aligned at this stratigraphic position and generally flattened on top; locally cemented with $CaCO_3$; brown (may be the Duncan Mills Member)	3.0

Liman Substage
Glasford Formation (continued)
Kellerville Till Member

6.	Till, calcareous, blue-gray, massive but well jointed throughout with oxidized rinds on joints; pebbly (P-125 lower part)	18.0

Kansan Stage
Banner Formation (type section)

5.	Till, leached, dark brown mottled with rusty brown and gray, clayey; truncated Yarmouth Soil; A-zone and upper part of B-zone removed by erosion; blocks of B-zone material occur locally as boulders in lower part of overlying till; secondary carbonate nodules present locally; upper contact sharp (P-124)	4.5
4.	Till, calcareous, massive, gray, compact, pebbly, cobbly, locally mottled with brown in upper part, jointed throughout; blocks or boulders of sand and silt with contorted bedding occur locally in middle part (P-123A upper; P-123 middle) ...	18.0
3.	Sand, fine to medium, calcareous, brown with gray streaks; grades downward to gray silt, calcareous, massive; contains some streaks of brown limonite cementation and some fossil snail shells (P-122 top; P-121; P-121A)	4.0
2.	Till, calcareous, compact, blue-gray at base, tan to light brown upward; contains streaks of coal fragments and a few thin streaks of gravel (P-119 base; P-119A lower; P-120 2 feet below top)	5.0

Harkness Silt Member

1.	Silt, calcareous, thinly bedded; alternating bands of ash gray and tan-brown; contains fossil snail shells throughout (P-1367X upper; P-1366X middle); to bottom of temporary drainage ditch........	5.0
	Total	89.0

TOULON SECTION

Measured in borrow pit excavation in NW NW SW Sec. 24, T. 13 N., R. 5 E., Stark County, Illinois, 1969.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

11.	Loess, leached, massive, tan-brown; surface soil in upper part (P-6846 1 foot above base)	5.0
10.	Loess, leached, massive, light brown to purplish brown, more clayey than above (P-6845)	1.0

Altonian Substage
Roxana Silt

9.	Silt, leached, massive, purple-brown; truncated Farmdale Soil; sharp contacts at top and bottom (P-6844)	1.0
8.	Silt, clay, and sand, leached, massive, gray-brown mottled with black, reddish brown, and gray; Chapin Soil; thin line of pebble concentrate at base; contains Mn-Fe pellets; sharp contacts top and bottom (P-6843)	1.0

Illinoian Stage
Jubileean Substage
Glasford Formation
Radnor Till Member

7.	Till; Sangamon Soil; truncated to the B_2-zone; massive, red-brown specked with black and gray-brown,	

clayey in B_2-zone; B_3-zone, yellow-tan-brown mottled with red-brown and gray-brown; contains some Mn-Fe pellets; grades downward to gray-tan-brown at base (P-6842 top; P-6841 3 feet below top) 6.0

6. Till, calcareous, massive, compact, gray-brown (P-6840 top; P-6839 base) 2.0

Monican Substage
Glasford Formation (continued)
Toulon Member (type section)

5. Sand, coarse, calcareous, massive, tan (P-6838 top) 4.0
4. Sand and gravel, calcareous, tan; surface slumping obscures bedding 5.0

Hulick Till Member

3. Till, calcareous, soft, dark gray, tan, and rusty tan; interzoned with irregular and apparently discontinuous lenses of sand and gravel (P-6837 middle) 6.0
2. Sand and gravel, calcareous, massive, tan to rusty tan; contains till balls (P-6836 base) 2.0
1. Till, calcareous, compact, indistinctly blocky to platy, silty, dark gray (P-6835) 2.0

Total 35.0

WASHINGTON GROVE SECTION

Measured in roadcuts in NW NW SW Sec. 11, T. 2 S., R. 5 W., Adams County, Illinois, 1964, 1965.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

4. Loess, massive, leached, tan; Modern Soil in top 5.5

Altonian Substage
Roxana Silt

3. Silt, leached, massive, tan-brown, clayey; contains some sand in basal part; Farmdale Soil at top 2.5

Illinoian Stage
Liman Substage
Glasford Formation
Kellerville Till Member (type section)

2. Till to level of road ditch at south end of exposure, wedging out to the north; Sangamon Soil developed in till at south end, continuing onto silt at north end; B-zone red-brown, clayey, massive; till, massive, leached in top 6 feet, jointed; calcite fillings along joints in calcareous, tan, pebbly till; beyond limit of till, the Teneriffe Silt that rests on the till converges with the Petersburg Silt that underlies the till, and the entire silt unit is classified as Loveland Silt (P-1974 calcareous till) 12.0

Petersburg Silt

1. Silt, thin bedded to indistinctly bedded, gray and tan, calcareous; contains some plates of caliche; to the north becomes part of the Loveland Silt beyond the limit of the till; Sangamon Soil is developed in Loveland Silt, which is leached 8 feet (P-1974A caliche; P-1974B; P-1974C from calcareous Loveland Silt) 20.0

Total 40.0

WEDRON SECTION

Measured in overburden of Wedron Silica Co., pit No. 1, SE SW Sec. 9, T. 34 N., R. 4 E., La Salle County, Illinois, 1957, 1959, 1964, 1965.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Richland Loess

15. Loess, leached; largely included in surface soil 3.0

Henry Formation
Batavia Member

14. Sand and gravel, poorly sorted, lenticular 3.0

Wedron Formation (type section)
Malden Till Member
Farm Ridge Drift

13. Till, silty, yellow-gray, calcareous (P-2082) 4.0
12. Sand and gravel, calcareous (P-2081) 2.0

Mendota Drift

11. Till, silty, bouldery, gray, calcareous 3.0
10. Sand, calcareous, tan 0.5

Arlington Drift

9. Till, tan, oxidized, calcareous (P-2080) 5.0
8. Silt and some sand, laminated, gray, calcareous (P-2078; P-2079 gray clay at top) 2.0

Dover Drift

7. Till, silty, gray, calcareous; contains a few pebbles (P-2077)..... 3.0
6. Sand and silt, gray, calcareous.... 1.0

Tiskilwa Till Member
Bloomington Drift

5. Till, pink, bouldery, massive, tough, calcareous; indistinct boulder pavement in middle part (P-2076 middle; P-496 base) 15.0

Lee Center Till Member
Atkinson Drift

4. Till, gray and tan, bouldery, compact, calcareous; sharp contact and indistinct boulder pavement at top (P-495, P-2075) 3.0
3. Sand and gravel, tan, loose, calcareous, locally cross-bedded and generally well bedded; irregular erosional contact at base; thickness varies (maximum thickness given here) (P-494 base) 20.0

Farmdalian Substage
Robein Silt — This not Robein will be new formation

Site JCF 4-9-71

2. Silt, clayey, pink to red and red-brown, calcareous, massive to indistinctly bedded but locally thin bedded and blocky; locally contains small lenses of fine sand; radiocarbon date of 24,000 ± 700 (W-79) determined on wood; conformable on unit below, but upper contact erosional and irregular; thickness varies (maximum thickness given here) (P-491 base; P-492 sand lens; P-493 top) 20.0
1. Silt, blue-gray and tan, massive, compact, calcareous; contains some clay and fine sand and local sandy streaks near top; contains molluscan fauna described by Leonard and Frye (1960); radiocarbon date of 26,800 ± 700 (W-871) determined on twigs and wood fragments from upper part; some zones strongly contorted by frost action; basal contact is irregular on eroded surface of St. Peter Sandstone (Ordovician); thickness varies (maximum thickness given here) (P-489 middle; P-490 top) 25.0

Total 109.5

ZION CHURCH SECTION

Measured in roadcuts in SE SE SW Sec. 9, T. 3 S., R. 8 W., Adams County, Illinois, 1963, 1964, 1965, 1969.

Thickness (ft)

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

9. Loess, massive, gray and yellow-tan, calcareous below the Modern Soil; contains limonite tubules and $CaCO_3$ concretions below soil (P-1982 8 feet below top of loess and 2 feet below top of calcareous zone; P-1981 13 feet below top; P-1980 17 feet below top) 19.0
8. Loess, yellow-tan, massive, weakly calcareous; gradational contacts... 1.5

Altonian Substage
Roxana Silt

7. Loess, pinkish tan to light brown, leached; Farmdale Soil in top; $CaCO_3$ nodules in middle; Chapin Soil in lower 1 foot; Mn-Fe pellets in lower part (P-1979 top; P-1978 1 foot above base) 4.0

Illinoian Stage
Loveland Silt

6. Silt, clayey, massive, leached, gray-tan; Sangamon Soil at top, uppermost foot accretion-gley; B-zone below accretion-gley 3 feet thick with Mn-Fe streaks and pellets, blocky to microblocky, mottled with gray, brown and black; contains some sand (P-2090 accretion-gley; P-2089 base) 8.0

Yarmouthian Stage
Banner Formation
Lierle Clay Member

5. Accretion-gley (clay and silt), leached, blocky when dry; some sand and sparsely dispersed pebbles of chert and quartz; gray-tan with reoxidized zone at top; Yarmouth Soil (P-2088) 3.0

Kansan Stage
Banner Formation (continued)

4. Till, leached, blocky, gray, brown; a few pebbles and cobbles of chert, quartz, quartzite, granite, and other igneous rocks; Mn-Fe streaks and pellets below accretion-gley 22.0

3. Till, calcareous, gray and tan, massive; consists of clay, silt, and sand, with scarce pebbles, cobbles, and boulders (P-1746) 5.0

Harkness Silt Member (type section)

2. Silt, calcareous, gray with tan-brown streaks, massive with indistinct color zonation; contains a few dispersed small pebbles and very scarce fragmentary snail shells; upper contact with till sharp but irregular; basal contact sharp (P-1745) 6.0

Nebraskan Stage

Enion Formation

1. Gravel, sand, and silt outwash, yellow-tan to red-brown, indistinctly bedded; pebbles include chert, quartz, quartzite, weathered granite and other igneous rocks; Afton soil (paratype); B-zone at top strongly developed, red-brown, clayey, tough; becomes less clayey downward (P-1744 top; P-1743 middle; P-7101 base) 5.5

Total 74.0

TABLE 7 — DESCRIBED STRATIGRAPHIC SECTIONS PREVIOUSLY PUBLISHED

(414 sections from 78 counties are arranged alphabetically, with citation to publication source)

Acme School, Henry County (Frye et al., 1969)
Adair South Auger, McDonough County (Wanless, 1957)
Adeline, Ogle County (Shaffer, 1956)
Albany South, Whiteside County (Frye et al., 1969)
Allis-Chalmers, Sangamon County (Johnson, 1964)
Altamont, Effingham County (MacClintock, 1929)
Alto Pass, Union County (Baker, 1928)
Alton Quarry, Madison County (Leighton, 1960; Leonard and Frye, 1960)
Annie's Lake, Christian County (Johnson, 1964)
Antioch Church, Macoupin County (Ball, 1952)

Baldbluff, Henderson County (Frye, Glass, and Willman, 1968)
Banner, Fulton County (Leonard and Frye, 1960)
Baylis, Pike County (Horberg, 1956; Leverett, 1899a)
Bear Creek, Macoupin County (Ball, 1952)
Beardstown, Cass County (DeHeinzelin, 1958)
Beaucoup Creek, Jackson County (Leighton and Willman, 1949)
Beaverton, Boone County (Frye et al., 1969)
Berlin School Auger, Stephenson County (Frye et al., 1969)
Bernard School, Henry County (Frye, Glass, and Willman, 1968; Frye et al., 1969)
Beuth School Auger, Winnebago County (Frye et al., 1969)
Bice School, Sangamon County (Johnson, 1964)
Big Creek, Clark County (Baker, 1928; Leighton and MacClintock, 1930; MacClintock, 1929)
Big Creek, Fulton County (Wanless, 1957)
Big Grove Township Auger, Kendall County (Willman and Payne, 1942)
Big Sister Creek, Fulton County (Wanless, 1955, 1957)
Bill's Run, Grundy County (Sauer, 1916)
Blackberry Township, Kane County (Horberg, 1953)
Bluffdale, Greene County (Leonard and Frye, 1960)
Boskydell, Jackson County (Lamar, 1925a)
Bradford, Stark County (Leighton and Willman, 1949)
Bradford East, Bureau County (Frye, Glass, and Willman, 1968)
Brookport, Massac County (Lamar, 1948)
Browning East, Schuyler County (Wanless, 1957)
Browns Mound, Scott County (Jones and Beavers, 1964; Leonard and Frye, 1960)
Bruce Township Auger, La Salle County (Willman and Payne, 1942)
Brush Creek, Bureau County (Horberg, 1953)
Brussels, Calhoun County (Rubey, 1952)
Buda, Bureau County (Baker, 1928)
Buda East, Bureau County (Frye and Willman, 1965a; Frye, Glass, and Willman, 1968)
Buffalo Prairie North, Rock Island County (Horberg, 1956)
Buffalo School Auger, La Salle County (Willman and Payne, 1942)
Bunker Hill, Macoupin County (Willman, Glass, and Frye, 1966)
Bunker Hill, Stephenson County (Shaffer, 1956)
Bureau, Bureau County (Cady, 1919)
Bureau Creek, Bureau County (Horberg, 1953)
Bureau South, Bureau County (Frye and Willman, 1965a; Horberg, 1953)
Byron West, Ogle County (Frye et al., 1969)

Cache River Bluff, Pulaski County (Pryor and Ross, 1962). See table 6.
Canton, Fulton County (Smith and Kapp, 1964)
Canton Road Mine, Peoria County (Wanless, 1957)
Capron North, Boone County (Frye et al., 1969)
Carlinville, Macoupin County (Ball, 1952)
Carlinville East, Macoupin County (Ball, 1952)
Carlinville Northeast, Macoupin County (Ball, 1952)
Carlinville Southeast, Macoupin County (Ball, 1952)
Carrollton, Greene County (MacClintock, 1929)
Carthage, Ogle County (Frye et al., 1969)
Carthage Northeast, Ogle County (Shaffer, 1956)
Case Creek, Rock Island County (Frye, Glass, and Willman, 1968)
Cedar Creek, La Salle County (Cady, 1919; Sauer, 1916)
Cedar Creek, Warren County (Savage, 1921; Savage and Nebel, 1921)
Cedar Creek Auger, Warren County (Wanless, 1929a)
Chamness, Williamson County (Willman, Glass, and Frye, 1963)
Chapin, Morgan County (Frye and Willman, 1965a; Willman, Glass, and Frye, 1966). See table 6.
Charleston City Farm, Coles County (Horberg, 1953)
Cherry Valley, Boone County (Frye and Willman, 1965a)
Choat "Badlands", Massac County (Leighton and Willman, 1949)

Christian Hollow Church, Stephenson County (Frye et al., 1969)
Clear Creek, Edgar County (MacClintock, 1929)
Clear Creek, Putnam County (Horberg, 1953)
Coal Creek, Morgan County (MacClintock, 1929)
Coleta, Whiteside County (Frye et al., 1969)
Collinson Creek, Vermilion County (Eveland, 1952)
Collinson Quarry, Rock Island County (Horberg, 1956)
Collinsville, Madison County (Jones and Beavers, 1964)
Collman School Auger, Stephenson County (Frye et al., 1969)
Coolidge Creek East, Winnebago County (Frye et al., 1969)
Copperas Creek, Fulton County (Wanless, 1957)
Copperas Creek, Peoria County (Wanless, 1957)
Copperas Creek, Rock Island County (Horberg, 1956; Savage and Udden, 1921)
Cottonwood Creek, Macoupin County (Ball, 1952)
Cottonwood School, Cass County (Frye and Willman, 1963b, 1965a; Jones and Beavers, 1964; Leonard and Frye, 1960). See table 6.
Covel Creek, La Salle County (Willman and Payne, 1942)
Crooked Leg Creek, La Salle County (Willman and Payne, 1942)
Cross Road School, Stephenson County (Frye et al., 1969)

Dallas City, Henderson County (Frye, Glass, and Willman, 1962)
Dalzell, La Salle County (Sauer, 1916)
Damascus East, Stephenson County (Frye et al., 1969)
Danvers (Rock Creek), McLean County (Frye, Glass, and Willman, 1962; Frye and Willman, 1965b; Glass, Frye, and Willman, 1964; Horberg, 1953)
Dayton Township Auger, La Salle County (Willman and Payne, 1942)
Dayton Township Gravel Pit, La Salle County (Willman and Payne, 1942)
Deadly Run, La Salle County (Willman and Payne, 1942)
Deer Creek, Whiteside County (Shaffer, 1956)
Deer Park Township Auger, La Salle County (Willman and Payne, 1942)
Dennison, Clark County (MacClintock, 1929)
De Pue, Bureau County (Baker, 1928; Frye, Glass, and Willman, 1962; Horberg, 1953)
Divine, Grundy County (Culver, 1922)
Dixon Creek East, Jo Daviess County (Willman and Frye, 1969)
Dixon Creek North, Jo Daviess County (Willman and Frye, 1969)
Dixon Creek South, Jo Daviess County (Willman and Frye, 1969)
Dixon Northwest, Lee County (Frye et al., 1969)
Dorsey, Madison County (Frye and Willman, 1963b)
Drainage Ditch, Vermilion County (Ekblaw and and Willman, 1955; Eveland, 1952; Leighton and Willman, 1953)
Duncan Mills Northeast, Fulton County (Wanless, 1957)
Duncan Mills Southeast, Fulton County (Wanless, 1957)

Eagle Township Auger, La Salle County (Willman and Payne, 1942)
East Alton, Madison County (Leighton and Willman, 1949)
East Bureau Creek, Bureau County (Horberg, 1953)
East Creek, Fulton County (Wanless, 1957)
East Peoria, Tazewell County (Horberg, 1953)
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204 p., 3 pls., 14 figs., 7 tables, glossary, index, 1970